TRANSACTIONS

AND

PROCEEDINGS

OF THE

NEW ZEALAND INSTITUTE

1901

VOL. XXXIV.

(SEVENTEENTH OF NEW SERIES)

EDITED AND PUBLISHED UNDER THE AUTHORITY OF THE BOARD OF GOVERNORS OF THE INSTITUTE

BY

SIR JAMES HECTOR, K.C.M.G., M.D., F.R.S.

DIRECTOR

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CORRIGENDA

Page 246, line 30. *For* C. Pattisson *read* C. Patteson.
Plate XIXA. *For* C. Pattisson *read* C. Patteson.
Page 134 and page 325. In explanation of plates *add* Plate XIXA
Map of Chatham Islands.

CONTENTS.

TRANSACTIONS.

I.—Miscellaneous.

II.—Zoology.

III.—BOTANY.

IV.—Geology.

V.—Chemistry and Physics.

I.—Miscellaneous—*continued.*

NEW ZEALAND INSTITUTE.

PROCEEDINGS.

WELLINGTON PHILOSOPHICAL SOCIETY.

AUCKLAND INSTITUTE.

PHILOSOPHICAL INSTITUTE OF CANTERBURY.

OTAGO INSTITUTE.

WESTLAND INSTITUTE.

HAWKE'S BAY PHILOSOPHICAL INSTITUTE.

NELSON INSTITUTE.

APPENDIX.

LIST OF PLATES.

NEW ZEALAND INSTITUTE.

ESTABLISHED UNDER AN ACT OF THE GENERAL ASSEMBLY OF NEW ZEALAND INTITULED "THE NEW ZEALAND INSTITUTE ACT, 1867."

ABSTRACTS OF RULES AND STATUTES.

Gazetted in the "New Zealand Gazette," 9th March, 1868.

Section I.

Incorporation of Societies.

1. No society shall be incorporated with the Institute under the provisions of "The New Zealand Institute Act, 1867," unless such society shall consist of not less than twenty-five members, subscribing in the aggregate a sum of not less than fifty pounds sterling annually for the promotion of art, science, or such other branch of knowledge for

which it is associated, to be from time to time certified to the satisfaction of the Board of Governors of the Institute by the Chairman for the time being of the society.

2. Any society incorporated as aforesaid shall cease to be incorporated with the Institute in case the number of the members of the said society shall at any time become less than twenty-five, or the amount of money annually subscribed by such members shall at any time be less than £50.

3. The by-laws of every society to be incorporated as aforesaid shall provide for the expenditure of not less than one-third of the annual revenue in or towards the formation or support of some local public museum or library, or otherwise shall provide for the contribution of not less than one-sixth of its said revenue towards the extension and maintenance of the Museum and Library of the New Zealand Institute.

4. Any society incorporated as aforesaid, which shall in any one year fail to expend the proportion of revenue affixed in manner provided by Rule 3 aforesaid, shall from thenceforth cease to be incorporated with the Institute.

5. All papers read before any society for the time being incorporated with the Institute shall be deemed to be communications to the Institute, and may then be published as Proceedings or Transactions of the Institute, subject to the following regulations of the Board of the Institute regarding publications:—

Regulations regarding Publications.

(*a.*) The publications of the Institute shall consist of a current abstract of the proceedings of the societies for the time being incorporated with the Institute, to be intituled "Proceedings of the New Zealand Institute," and of transactions, comprising papers read before the incorporated societies (subject, however, to selection as hereinafter mentioned), to be intituled "Transactions of the New Zealand Institute."

(*b.*) The Institute shall have power to reject any papers read before any of the incorporated societies.

(*c.*) Papers so rejected will be returned to the society in which they were read.

(*d.*) A proportional contribution may be required from each society towards the cost of publishing the Proceedings and Transactions of the Institute.

(*e.*) Each incorporated society will be entitled to receive a *proportional* number of copies of the Proceedings and Transactions of the Institute, to be from time to time fixed by the Board of Governors.

(*f.*) Extra copies will be issued to any of the members of incorporated societies at the cost-price of publication.

6. All property accumulated by or with funds derived from incorporated societies, and placed in charge of the Institute, shall be vested in the Institute, and be used and applied at the discretion of the Board of Governors for public advantage, in like manner with any other of the property of the Institute.

7. Subject to "The New Zealand Institute Act, 1867," and to the foregoing rules, all societies incorporated with the Institute shall be entitled to retain or alter their own form of constitution and the by-laws for their own management, and shall conduct their own affairs.

8. Upon application signed by the Chairman and countersigned by the Secretary of any society, accompanied by the certificate required under Rule No. 1, a certificate of incorporation will be granted under the seal of the Institute, and will remain in force as long as the foregoing rules of the Institute are complied with by the society.

Section II.

For the Management of the Property of the Institute.

9. All donations by societies, public departments, or private individuals to the Museum of the Institute shall be acknowledged by a printed form of receipt, and shall be duly entered in the books of the Institute provided for that purpose, and shall then be dealt with as the Board of Governors may direct.

10. Deposits of articles for the Museum may be accepted by the Institute, subject to a fortnight's notice of removal, to be given either by the owner of the articles or by the Manager of the Institute, and such deposits shall be duly entered in a separate catalogue.

11. Books relating to natural science may be deposited in the Library of the Institute, subject to the following conditions:—

(*a*.) Such books are not to be withdrawn by the owner under six months' notice, if such notice shall be required by the Board of Governors.

(*b*.) Any funds especially expended on binding and preserving such deposited books at the request of the depositor shall be charged against the books, and must be refunded to the Institute before their withdrawal, always subject to special arrangements made with the Board of Governors at the time of deposit.

(*c*.) No books deposited in the Library of the Institute shall be removed for temporary use except on the written authority or receipt of the owner, and then only for a period not exceeding seven days at any one time.

12. All books in the Library of the Institute shall be duly entered in a catalogue, which shall be accessible to the public.

13. The public shall be admitted to the use of the Museum and Library, subject to by-laws to be framed by the Board.

Section III.

The laboratory shall for the time being be and remain under the exclusive management of the Manager of the Institute.

Section IV.

(Of Date 23rd September, 1870.)

Honorary Members.

Whereas the rules of the societies incorporated under the New Zealand Institute Act provide for the election of honorary members of such societies, but inasmuch as such honorary members would not thereby become members of the New Zealand Institute, and whereas it is expedient to make provision for the election of honorary members of the New Zealand Institute, it is hereby declared,—

1. Each incorporated society may, in the month of November next, nominate for election, as honorary members of the New Zealand Institute, three persons, and in the month of November in each succeeding year one person, not residing in the colony.
2. The names, descriptions, and addresses of persons so nominated, together with the grounds on which their election as honorary members is recommended, shall be forthwith forwarded to the Manager of the New Zealand Institute, and shall by him be submitted to the Governors at the next succeeding meeting.
3. From the persons so nominated the Governors may select in the first year not more than nine, and in each succeeding year not more than three, who shall from thenceforth be honorary members of the New Zealand Institute, provided that the total number of honorary members shall not exceed thirty.

ROLL OF INCORPORATED SOCIETIES.

NAME OF SOCIETY.	DATE OF INCORPORATION.
WELLINGTON PHILOSOPHICAL SOCIETY -	10th June, 1868.
AUCKLAND INSTITUTE - - - -	10th June, 1868.
PHILOSOPHICAL INSTITUTE OF CANTERBURY	22nd Oct., 1868.
OTAGO INSTITUTE - - - - -	18th Oct., 1869.
WESTLAND INSTITUTE - - - -	21st Dec., 1874.
HAWKE'S BAY PHILOSOPHICAL INSTITUTE -	31st Mar., 1875.
SOUTHLAND INSTITUTE - - - -	21st July, 1880.
NELSON INSTITUTE - - - - -	20th Dec., 1883.

OFFICERS OF INCORPORATED SOCIETIES, AND EXTRACTS FROM THE RULES.

WELLINGTON PHILOSOPHICAL SOCIETY.

OFFICE-BEARERS FOR 1902.—*President*—W. T. L. Travers, [illegible]S.; *Vice-presidents*—Sir J. Hector, K.C.M.G., M.D., F.R.S., and R. L. Mestayer, M.Inst.C.E.; *Council*—H. N. McLeod, E. Tregear, F.R.G.S., Martin Chapman, G. Hogben, M.A., R. C. Harding, G. V. Hudson, and Professor Easterfield, M.A.; *Secretary and Treasurer*—R. B. Gore; *Auditor*—Thomas King.

Extracts from the Rules of the Wellington Philosophical Society.

5. Every member shall contribute annually to the funds of the Society the sum of one guinea.

6. The annual contribution shall be due on the first day of January in each year.

7. The sum of ten pounds may be paid at any time as a composition for life of the ordinary annual payment.

14. The time and place of the general meetings of members of the Society shall be fixed by the Council, and duly announced by the Secretary.

AUCKLAND INSTITUTE.

OFFICE-BEARERS FOR 1902.—*President*—E. Roberton, M.D.; *Vice-presidents*—J. Stewart, M.I.C.E., and Professor H. W. Segar; *Council*—Professor F. D. Brown, C. Cooper, H. Haines, F.R.C.S., E. V. Miller, T. Peacock, D. Petrie, J. A. Pond, H. Swale, M.D., Professor H. A.

Talbot-Tubbs, Professor A. P. W. Thomas, F.L.S., and J. H. Upton; *Secretary and Curator*—T. F. Cheeseman, F.L.S., F.Z.S.

Extracts from the Rules of the Auckland Institute.

5. Any person desiring to become a member of the Institute shall be proposed and seconded by two members of the Institute, and shall be balloted for at the next meeting of the Council.

6. The annual subscription shall be one guinea. Members may at any time become life-members by one payment of ten guineas in lieu of future annual subscriptions.

9. The annual subscription shall become due on the first day of April for the year then commencing. The first year's subscription of a new member shall become due on the day of his election.

30. An annual general meeting of the Institute, convened by advertisement or circular, shall be held in the month of February in each year.

32. Ordinary meetings for the reading of papers, and for transacting the general business of the Institute, shall be called at such times as the Council shall decide.

PHILOSOPHICAL INSTITUTE OF CANTERBURY.

Office-bearers for 1902.—*President*—J. B. Mayne, B.A.; *Vice-presidents*—C. C. Farr and A. E. Flower; *Hon. Secretary and Treasurer*—Dr. Charles Chilton; *Council*—Captain F. W. Hutton, Dr. W. P. Evans, R. M. Laing, L. Cockayne, R. Nairn, and Miss Olliver; *Hon. Auditor*—George Way, F.I.A.N.Z.

Extracts from the Rules of the Philosophical Institute of Canterbury.

8. Every member of the Institute other than honorary shall pay one guinea annually as a subscription to the funds of the Institute. The subscription shall be due on the 1st January in each year.

9. Members may compound for all annual subscriptions of the current and future years by paying ten guineas.

15. The ordinary meetings of the Institute shall be held monthly during the months from May to November, both inclusive, on such day as the Council may determine.

OTAGO INSTITUTE.

Office-bearers for 1902.—*President*—Professor Benham; *Vice-presidents*—F. R. Chapman and C. W. Chamberlain; *Hon. Secretary*—G. M. Thomson; *Hon. Treasurer*—W. Fels; *Council*—Professor Park, Dr. Hocken, Dr. Colquhoun, Dr. Marshall, A. Hamilton, T. D. Pearce, and A. Bathgate; *Auditor*—D. Brent.

Extracts from the Constitution and Rules of the Otago Institute.

2. Any person desiring to join the society may be elected by ballot, on being proposed in writing at any meeting of the Council or society by two members, and on the payment of the annual subscription of one guinea for the year then current.

5. Members may at any time become life-members by one payment of ten pounds and ten shillings in lieu of future annual subscriptions.

8. An annual general meeting of the members of the society shall be held in January in each year, at which meeting not less than ten members must be present, otherwise the meeting shall be adjourned by the members present from time to time until the requisite number of members is present.

(5.) The session of the Otago Institute shall be during the winter months, from May to October, both inclusive.

WESTLAND INSTITUTE.

Office-bearers for 1902.—*President*—Dr. Teichelmann; *Vice-president*—J. B. Lewis; *Hon. Treasurer*—R. McNaughton; *Trustees*—Messrs. Beare, Clarke, Heinz, Michel, Hickson, Morton, Park, Perry, Macfarlane, Mahan, Dawes, and Dr. Macandrew.

Extracts from the Rules of the Westland Institute.

3. The Institute shall consist (1) of life-members—*i.e.*, persons who have at any one time made a donation to the Institute of ten pounds ten shillings or upwards, or persons who, in reward of special services rendered to the Institute, have been unanimously elected as such by the committee or at a general half-yearly meeting; (2) of members who pay two pounds two shillings each year; (3) of members paying smaller sums, not less than ten shillings.

5. The Institute shall hold a half-yearly meeting on the third Monday in the months of December and June.

HAWKE'S BAY PHILOSOPHICAL INSTITUTE.

Office-bearers for 1902.—*President*—J. P. D. Leahy, M.B., M.S., B.A., D.P.H.; *Vice-president*—T. C. Moore, M.D.; *Council* — W. Dinwiddie, T. Hall, H. Hill, B.A., F.G.S., F. Hutchinson, jun., J. S. Large, T. Tanner; *Hon. Secretary*—James Hislop, District School; *Hon. Treasurer*—J. W. Craig; *Hon. Auditor*—G. White.

Extracts from the Rules of the Hawke's Bay Philosophical Institute.

4. The annual subscription for each member shall be one guinea, payable in advance on the first day of February in each year.

6. Members may at any time become life-members by one payment of ten pounds ten shillings in lieu of future annual subscriptions.

(5.) The session of the Hawke's Bay Philosophical Institute shall be during the winter months from May to October, both inclusive; and ordinary meetings shall be held on the second Monday in each of those six months, at 7.30 p.m.

SOUTHLAND INSTITUTE.

Office-bearers. — *Trustees* — Ven. Archdeacon Stocker, Rev. John Ferguson, Dr. James Galbraith.

NELSON INSTITUTE.

Office-bearers for 1902.—*President*—H. W. Robinson; *Vice-president*—D. Grant; *Hon. Secretary and Treasurer*—A. J. Redgrave; *Acting-Curator of Museum*—W. F. Worley; *Librarian*—B. Reeves.

Extracts from the Rules of the Nelson Institute.

4. Members shall be elected by ballot.

6. The annual subscription shall be one guinea.

7. The sum of ten guineas may be paid in composition of the annual subscription.

16. Meetings shall be held on the second Monday in every month.

23. The papers read before the Society shall be immediately delivered to the Secretary.

TRANSACTIONS

TRANSACTIONS

OF THE

NEW ZEALAND INSTITUTE,

1901.

I.—MISCELLANEOUS.

Art. I.—*Presidential Address.*

By Jas. Stewart, C.E.

[*Read before the Auckland Institute, 3rd June, 1901.*]

We this night commence the thirty-fourth session of our Institute, a fact which carries our existence practically over one-third of a century; and, although it might be excusable to utilise this landmark as a peg on which to hang a retrospect of the past and anticipations more or less prophetic or imaginative in respect to the future, I prefer to touch lightly on this scope, and leave it to the occupier of this chair sixteen years hence, when the jubilee of the Institute will be celebrated in, there is no room for doubt, a manner befitting the occasion, and with the participation of, I hope, all of those whom I now see before me. Nevertheless, I am deeply sensible of the privilege I now enjoy of opening our first session in the new century, and it is pleasing to be able on such an occasion to congratulate the Institute on its solid and prosperous condition. We are able to keep up a steady, if not large, increase in all sections of the Museum, and in the ethnological section especially we may claim to lead the colony. Our roll of membership has taken a turn upwards, with every prospect of a yearly balance on the right side, the result in no small degree of the lectures, scientific and popular, which for many years past have been given, often at no small

trouble and some expense, by those who have thus evinced in such a practical manner their interest in the work.

When I addressed you on a similar occasion to the present eleven years ago some of the present applications of science were in comparative infancy, and the advance that has been made since then offers a tempting opening to enlarge on what may be achieved in the future. But I have no intention of inflicting on you a tirade in the gushing style of which we have had a good deal of experience since the commencement of the century. Some of the conclusions reached in these predictions might eventuate if the law of gravitation could be repealed. But just as we have experienced the possible, so also we have a clearer conception of what is impossible; just as we have learned the possibilities of electric transmission of heat, light, and force, so have we learned the laws by which these things are governed, and which are as immutable as those pertaining to the older science of hydraulics. When one takes up a specimen of these florid predictions, such as I have now before me in a cutting from an American newspaper, and eliminates therefrom all that is equivalent to perpetual motion—and, singular to say, many things that are already in use; others, again, long known but not in use—it is wonderful how little remains of what is possible and at the same time new.

There are, however, among those who have been forecasting future possibilities the names of some who have scored their mark indelibly in the annals of time. And if, as is asserted, Nikola Tesla predicts that electric messages and power will be sent from England to Australia without wires, we have no scientific warrant for disbelief, although we have not the smallest foundation in our present experience for hoping that such a thing may be possible.

But to enter into a train of speculative thought on these and kindred subjects on this occasion would be somewhat out of place, and I shall therefore endeavour to enlist your attention in matters having a more or less practical bearing and influence on every-day life. This opens out a very extensive field of vision, far too much for either your time or patience, and I will endeavour to exhaust neither.

The advance of engineering during the last fifty years has been suggested as a theme of general interest, and it is to me in many points attractive, for it is just fifty years ago last New Year since I entered to serve my time to the work of my life, a raw youth of eighteen fresh from Ian Maclaren's Scots Grammar School. I will therefore glance at a few of the changes which have taken place in the practice of what has been happily defined as the "art of directing the great sources of power in nature for the use and convenience of man."

Sixty years ago the design of bridges adhered, with few exceptions, to the arch or suspension type. But stone or brick arches were going out, and designs in cast or wrought iron were coming in. The suspension type had been tried for railway-work and found unsuitable without such application of stiffening as led it practically to partake quite as much of the girder type as of suspension. The disastrous breakdown of the Dee Bridge, near Chester, in which a deep cast-iron girder was reinforced in a rather unscientific manner by malleable-iron ties, led to the abandonment of cast-iron for all but very small spans, and even for such it has long disappeared. With the last of the "forties" came the tubular bridges of Conway and Britannia; but with the succeeding great Victoria Bridge over the St. Lawrence at Montreal this design may be said to have been abandoned. The design is not economical, really very much the reverse, but the mathematical investigations necessary to its evolution bore immediate fruit in the inception and development of the open-girder pattern, which in some of its many modifications has become the standard of all long and short span bridges the design of which is not governed by æsthetic traditions. It will be readily granted that it is the size of the span, and not the mere length of the structure, that stamps the importance of a bridge, and the advance of engineering in this particular in fifty years cannot be more forcibly illustrated than by the comparison put forth by Sir Benjamin Baker — that is to say, the span of the Britannia Bridge, 460 ft., is to that of the Forth Bridge, 1,710 ft., as a newly born babe is to a life-guardsman. The bridge now in progress over the St. Lawrence at Quebec is to have a span 90 ft. longer than that of the Forth, and the designs of the proposed great suspension-bridge over the Hudson, between New York and Hoboken, show a span of 2,700 ft., or 60 ft. more than half a mile.

In direct contrast to bridges are tunnels, and in this line an enormous advance has been made, not only in the magnitude of the works, but in the facility and certainty with which operations can be carried out under all circumstances, even to driving under the Thames at Blackwall with only a few feet of mud between the water and the lining of the tunnel. Driving railway-tunnels for miles under cities like London or Glasgow is now such an every-day occurrence as to call for no remark. During the last half-century the Mont Cenis Tunnel, seven miles and a third, and that of the St. Gothard, nine miles and a quarter, have been constructed, and at the present time the Simplon is being pierced by twin tunnels of twelve miles and a half in length.

Turning to railways, the principal departure seems to be in the direction of application to steep and mountainous

countries formerly considered to be inaccessible to the locomotive. It is true that more than sixty years ago a gradient of 1 in 37½ was worked by ordinary locomotives on the Bromsgrove–Lickey Incline, between Birmingham and Oxford, but that was exceptional. Soon, however, in the period under review, it was recognised that railways must be adapted to circumstances, and not limited to conventional gradients or curves. Main lines in North and South America have now many hundreds of miles of gradients of 1 in 25 and 1 in 20. What this means may be imagined when it is considered that it is not far from double the rate of ascent of the heaviest of our New Zealand lines as worked with ordinary locomotives. It is worthy of remark that we have, in some of its phases, a renewal of the "battle of the gauges," which in the early "forties" was being fought through many parliamentary campaigns. And it is somewhat disquieting to find that there are some among us who, ignoring the lessons of the past, would calmly condemn a future generation to the trouble and expense which a break of gauge forced on Britain and America, a trouble which will loom more and more into view as a disturbing factor in the railway policy of the Australian Commonwealth. Locomotives have been practically trebled in weight and power during the last fifty years. The express speeds are somewhat, but not very much, higher—that is, on the average. But we are promised within the next two years or so the startling development of railway speed up to 120 miles per hour. Some anticipate much more. This is by the monorail system, which Mr. Behr has pushed into prominence, and which is likely to be exploited on the historic field, in railway history, of Liverpool and Manchester. Such speeds can only be attained by carriages not liable to derailment, and propelled by other than reciprocating machinery. It is possible that, for express passenger traffic and under exceptional conditions, this system may come into use. But I fear that several defects, such as shunting difficulties and others, inherent in its design will prevent its adoption otherwise.

In marine engineering we see a most marvellous advance, and it would take all the time at our disposal this night to follow up, step by step, the steady march in the direction of speed and reduction of fuel per unit of power. The double, treble, and quadruple phases of compound engines, with proportionately high initial steam-pressure and high piston-speed, have worked results which in the early "fifties" would have been declared impossible by nearly all the marine engineers in Great Britain. I say nearly all. I might extend it to all but one. In 1852 John Elder, the descendant of a race of grand old Fifeshire mechanics, and the possessor of all that

can be conferred by heredity in such a case, entered into business on the Clyde. Although the compound engine had been invented and in mining use in Cornwall at the close of the eighteenth century, it was left for John Elder to see the vast possibilities of the application of the principle to marine work. Previous to his time the steam-pressure used in marine boilers was about 7 lb. per square inch, and the difficulty in introducing the compound design lay principally in the deeply rooted prejudice existing against high pressures at sea. In 1853, however, Messrs. Randolph, Elder, and Co. commenced the innovation entailing the most radical departure from former practice. I well remember the opposition set up, alike by owners and the engine-room staff, and I watched with much interest the steady, if not rapid, triumph of high initial pressure and expansion to extreme limits in separate cylinders. John Elder died in 1869, at the early age of forty-three. Had he survived to the present day, what would he have seen as the result of his sound judgment of fifty years ago? He would have seen marine boilers carrying steam at 280 lb. to the inch, and expanding in three or four stages through five cylinders, with piston-speeds of 900 ft. per minute. He would have seen the consumption of fuel at sea reduced from more than 6 lb. per horse-power per hour to less than 1 lb. And, solely as the outcome of these results, he would have seen the Atlantic Ocean virtually a ferry, crossed by more than half a million of passengers last year, and our own colony, for the Panama service of which he built the "Rakaia," served with steam-liners not one of which would have been possible under the old system. And, lastly, he would have seen the cargo-steamer "Inchmarlow" carrying 1 ton one sea mile by the combustion of one-third of an ounce of coal, which, taking the price at 15s. per ton, is equivalent to carrying 1 ton 550 miles for 1d. But the most startling innovation in the marine engine is undoubtedly the steam-turbine of the Hon. Mr. Parsons. By this means velocities have been reached of forty-three statute miles per hour, with an utter absence of that vibration which, at high speeds, is at once so distressing and destructive. Whether the steam-turbine can be applied to an Atlantic liner remains to be seen. There are several drawbacks inherent to the design, the principal of which is the impossibility of reversing the turbine, so that separate machinery has to be provided for going astern, and which is allowed to run loose when the vessel is going ahead. It is certainly not in its favour that, even in the small vessels in which this turbine has been tried, the power has to be applied through three propeller-shafts, each with three screws, the whole revolving at the enormous velocity of two to three thousand revolutions per minute.

Full efficiency also can only be obtained when full power is being exerted. At half and quarter speeds the loss of efficiency is very great, and as yet the efficiency is at best very considerably below that of the average ordinary marine engine of the day. But in this turbine the long-sought realisation of a successful rotary engine has been attained.

In electrical engineering we have the third great branch of the profession; and it is one which, in its far-reaching ramifications, already exceeds the most diversified practice of the conventional civil engineer or his brother of the marine. To draw a contrast between electrical engineering fifty years ago and to-day would indeed be comparing small things with great. The electrical engineer as known to us now had no existence in those days. Electricity was employed, we may say, in only two works of commercial importance—those of electroplating and telegraphy. The original patents for both of these applications were overridden by what was called "magnetic plating" and the "magnetic telegraph." Permanent magnets were used in both cases, and it was not until it was found that electro-magnets could be substituted that the phenomenal advance in the science and practice of electricity took place. To speak in detail of the evolution of the electrical engineer is not my purpose. My endeavour is to interest you, not to weary you if I can avoid it; but I may mention one circumstance which stands out boldly in my memory in the light of present experience. My worthy old friend the rector of the Scots Grammar School aforesaid, in his lectures on electricity, held it to be impossible that the electric light should be commercially successful. His reasoning was based on the difference between the atomic weights of carbon and zinc. At that time this was given as 6 to 32, now more accurately stated as 11·97 to 64·9, but the ratios are very nearly the same. Had the electric light been possible of production only by the primary battery, in which zinc is the fuel, the old gentleman would have been right, for 1 ton of coal, or rather of carbon, would go as far in chemical combination as more than 5 tons of zinc. But the invention of the dynamo gave coal its opportunity; and yet it is at a heavy disadvantage, in so far as it cannot be applied directly in a primary battery like zinc, but must be used through the intervention of the steam or gas engine. Now, the steam-engine is the most wasteful of prime movers, so far as the conversion of the thermodynamic value of fuel into work is concerned. It has an efficiency of only from 10 to 12 per cent., and very seldom reaches 15 per cent., while the efficiency of the primary battery may be averaged at 90 per cent. or more. If, therefore, carbon could be used

directly in a primary battery as zinc is, a saving of fuel of about 75 per cent. would result. With a prize like this in prospect we cannot wonder that for many years a primary carbon battery has been the dream of electrical inventors. But, although thermo cells of several kinds are known, we are practically no nearer the realisation, and I very much fear that we shall never see the boilers of an Atlantic liner replaced by electric batteries, into which a few stokers working in a cool and pleasant atmosphere will shovel one-seventh of the coal now required by steam. The difficulties attending the practical application of such batteries would be enormous, and may be clearly conceived by supposing zinc to be as plentiful and cheap as coal, and to form the fuel, in fact, as we would like to see carbon. We have only to imagine the number, dimensions, and arrangement of cells, each of a pressure of about one volt, which would have to be grouped and arranged in serried masses to give out from 15,000 to 30,000 horse power. No; I am more than doubtful of the utility, for marine purposes at all events, of the primary carbon battery, even if it does become a fact.

In electric traction the last decade of the century has furnished probably the greatest revolution ever witnessed in the realm of applied science, although so far as Great Britain and the Continent of Europe are concerned it has only just commenced. There are many reasons for this great success, but I have no intention of entering into them in detail at this time. I hope that before our meeting next year on a similar occasion to the present we shall have a practical illustration of electric traction in our midst. The scale on which it is being installed in America is immense. The New York elevated street railway is now being transformed from a locomotive to an electric system, and the traffic with which it has to cope may be imagined when the record of two consecutive days' work is looked at. On these days 1,700,000 passengers were carried. During the heaviest rush of traffic 280 trains, or 1,280 cars, were run per hour, and during twenty-four hours 4,820 trains were despatched on the various sections. The electric power on this system, when the installation at present in progress is complete, is stated to be eight units of 8,000-horse power, or a total of 64,000-horse power. In London the work of transformation of the metropolitan and metropolitan district railways is in progress, and it will be a welcome change from the smoky dungeon-looking holes they are now to the white walls and clear air they will in a short time present to a vastly increased traffic. While on the question of electric traction it may be mentioned that a discussion has arisen in all sincerity respecting the possibility of replacing locomotive traction on railways in

general by electric power. It is held by some that power-stations located at regular distances along the lines could, by the three-phase system, transmit energy at a more economical rate than is obtained with locomotives. The question is indeed a large one, but is bound to be threshed out to a finality. It is like the question of change of gauge. The enormous sacrifice of plant involved delayed that for many years, but it had to be faced in the end, and so it may in this instance also.

During the last fifty years, but at somewhat long intervals, the subject of wireless telegraphy has come before the public. The first exponent of this, so far as I know, was a native of Forfarshire, Mr. J. Bowman Lindsay. I well remember his experiments in transmitting signals across the River Tay, near Perth, during the year I left Home, now just forty-two years ago. Later Mr. Lindsay essayed to transmit signals between Dundee and the southern shore near Newport. His method was by conduction, making the earth or water, in fact, act as conductors between pairs of earth-plates on either side of the space over which he wished to communicate. The possibilities of wireless telegraphy under this system are extremely limited and of no practical value, and it is not hard to understand why the labours of Lindsay—one of the most earnest and self-sacrificing workers in practical science the country has ever known—were not taken up for actual use.

Towards the end of the century the experiments of the late lamented Hertz demonstrated the existence of a medium which, ever since the days of Newton, was suspected as the agent by which the laws of gravitation and light act in force throughout all space. This medium has usually been designated the "ether," and now the tendency of thought is towards identifying it with electricity itself. Whether this is so or not, it is certain that, in accordance with the number of billions of vibrations or etheric waves per second, there appear to our senses the component parts of light as separated by a refracting prism. Beyond the range of vibrations which give out the spectrum are the Rontgen or *x* rays, which have the power of penetrating many otherwise opaque substances, as the solar rays do glass. And, curiously enough, the Hertzian waves are in frequency placed far below those of the dullest red, the lowest of the spectrum, and yet they have the power of vibrating through solids, or what we have hitherto been calling solids. Had Hertz survived he most certainly would have followed up his discoveries to the point of controlling the despatch and receipt of the etheric waves, and by reinforcing them by an ordinary relay effect what is now known as wireless telegraphy. This work has been taken up by Marconi, Dr. Lodge, F.R.S., and others; but to Marconi seems to be

due the form of coherer which appears to be the most sensitive and practical method of catching vibrations in the ether set in motion by powerful sparks discharged it may be a hundred miles distant.

The question now arises, To what extent, from a commercial point of view, is wireless telegraphy likely to come into use? Gushing writers, in crowding together the coming achievements of the century, take for granted that all wires, alike for telegraph and telephone, will be abolished. Granted that perfection is reached in practice, and that it is possible to dispense with telephone-wires between any two instruments, it will be readily admitted that a system by which a receiver could respond to and translate into speech all or any of the etheric vibrations set up by thousands of instruments would be of no value, to say the least of it. Hence Marconi endeavoured to devise means by which the vibrations could be reflected, or, at all events, very much strengthened, in a given direction. But it is hard to conceive Hertzian waves, which are supposed to be able to pass through stone walls, being reflected by anything. This reflection idea, therefore, has not been much in evidence of late. But it is asserted that a receiver may be tuned so as to syntonize with a particular transmitter, and that signals would be intelligible only between these two. Granted again, what follows in practice? Each subscriber must be supplied with instruments tuned to those of every other member of the Exchange. This, of course, is unthinkable, and therefore for telephony wires cannot be superseded. For telegraphy it might be possible to use a cryptograph, by which messages might be deciphered only by those holding the key. It may be objected that all ciphers are solvable by scientific methods, but there is one very simple instrument, known as the Wheatstone Cryptograph, which is absolutely unsolvable without the key, and that key may be varied through millions of commutations.

It is thus more than doubtful if wireless telegraphy may become commercially useful. But there is a large and very important field of usefulness otherwise open. At sea especially, both in peace and war, it must become of immense importance. We all remember the long search that took place some time ago after two disabled steamers. Had they, and also those engaged in the search, been supplied with Marconi's instruments, the work would have extended to days instead of weeks or months, and been one of system instead of chance. So, also, for enabling an admiral to communicate with his fleet during foggy weather, or with detached ships or squadrons, and for lighthouses and lightships communicating with shore stations, the invention appears to be perfect. It

is stated that, owing to some atmospheric conditions, this system has not been a conspicuous success in South Africa. If so, it would seem that there is some subtle connection between the ether and the atmosphere that is rather disturbing to the ideas we have been forming on the subject. But wireless telegraphy as yet is only effected by bold and explosive discharges which generate the waves, and who can say that the new century may not see the same effect produced by vibrations as mild as those set up between the transmitter and receiver of an ordinary telephone circuit? Those vibrations represent an electric current so feeble that no known galvanometer can even detect their presence, and yet they effect the most delicate reproductions of the human voice. Nothing is known of the still more feeble currents circulating in the human brain; but that in the cells of that organism currents are transmitted through the nerves, and having performed the behests of the will are returned, much in the same manner as in ordinary electrical work, can hardly be doubted. And, further, it only requires the supposition that among the millions of human-brain batteries two may be now and then found so accurately syntonized as to respond without the conducting nerves being physically joined, and that Hertzian waves may in this manner be the foundation of thought-reading, of the possibility of which many very startling demonstrations have been given. It is also possible that by much training and practice certain individuals may acquire the power of syntonizing the transmitting cells of their brains with the receptive cells of others, who may be already nearly in syntony with them, and thus the phenomena of hypnotism may yet be elucidated.

I have, I fear, allowed this rather jerky and disjointed disquisition, if I may presume to use the term, to extend to undue length, and I will endeavour to utilise the remaining time at my disposal by touching on one or two subjects having general interest, and which are calculated to affect the well-being of our colony. Foremost among these stands technical education. I observe with pleasure that this subject has been engaging the attention of the Chief Justice, Sir Robert Stout, and, after his master-mind and perspicuity of diction, I might well let the matter rest. But if only to add my testimony to the truth of his line of argument, and recall a few illustrations within my experience, I have the temerity to follow on. The first thing that strikes me is what is commonly understood by the term "technical education." We have had a technical school in our midst for some years, and towards gaining an insight as to what the term is understood locally to mean I very gladly availed myself of an opportunity of visiting it and seeing for myself. Well, I saw a school in which

various handicrafts were practised and taught, together with the elements of machine-drawing. The workmanship was in most cases very good, in some cases perfect. A great deal of attention was devoted to carving in wood, and many very creditable productions were to be seen finished or in progress. The whole reflected much credit on the promoters of the institution so far as the scope of teaching went. But that does not represent what technical education in its true sense means, which, as it happens, has been defined by Act of Parliament. I have had many opportunities of observation, and have come to two conclusions bearing on technical teaching. The first is: A youth cannot be taught a given trade at any such school in a manner to enable him to take his place among those who have served a regular apprenticeship to that trade. Nothing can take the place of, or effect the same results as, an apprenticeship, regular or not, but in any case comprising, say, four or five years of actual work and earnest application. Of course, there are exceptions, as now and then there may arise a Nasmyth, who was self-taught and served no apprenticeship and yet was perfect in his workmanship. The second point I note is that, of all things a youth can try, the use of his hands in mechanical handicraft is the easiest to acquire, notwithstanding the length of time it takes to perfect his workmanship. This must be understood as in comparison with anything requiring the use of his brains. I cannot too strongly emphasize the difference that exists between a mechanic and a mechanical workman. Hugh Miller's friend, David Fraser, who was so expert a stone-cutter that he could easily do, and regularly did, as much work as three ordinary men, was a mechanical workman of the first order, but nothing more—a human machine, in fact. On the other hand, the late Lord Armstrong, who began life as a solicitor, was no workman, and never even acquired the art of the draughtsman, but he was by nature a mechanic, and became one of the foremost mechanicians of the age.

There are, of course, some handicrafts ever so much more difficult to acquire than others; but I am safe in estimating, as the result of a lengthened and close observation of a good few representative trades, that not more than one in five hundred of good workmen gets further than that stage by the exercise of mental capacity. I have, to be on the safe side, taken the above proportion; but I fear that were a close investigation possible the result would be much more unfavourable. This is under the system of no higher education than that to be obtained at the bench; and the work of joinery plumbing, &c., which I saw at the technical school goes very little further. I need not say that such is not the system of technical training which has worked so great a change in

Germany and elsewhere. There the great aim is to prepare the intellect to receive and master the scientific basis of all construction or other process of manufacture. Under such a course a very large proportion of the students, who depend on the workshops for their skill and expertness with their hands, rapidly learn to become more than mere human automata. I know that I am treading on much-debated ground, but I feel sure that a little observation of the results of this dual training will support my conclusions, which are in accordance with those of the Chief Justice and a host of eminent men who are devoting much time to the study of ways and means towards the elevation of the masses.

The late Sir Joseph Whitworth left a very large endowment for the establishment of technical scholarships. The conditions of entry therein were very clearly outlined by him and formulated by the trustees, and are in principle very simple. An intending student who has acquired an elementary knowledge of any of the sciences—say, of chemistry, geometry, or other branches of mathematics—may be a workman in any of the trades allied to engineering; or he may be a scientific or mathematical student who has acquired a certain well-defined but not severe degree of expertness in the use of hand-tools. I am speaking from memory of the first regulations for the scholarships. There may be alterations in some respects since, but in any case the degree of Wh.Sc. carries great weight in the scientific and technical world. I have mentioned this foundation particularly because it was the creation of one of the small minority I speak of—one who, not content with being unsurpassed as a workman, used his great abilities towards the perfection of tool and machine design and manufacture, having a clear intuition of the possibilities of the advancement of the British workman with the necessary educational facilities at his command. But in addition to the Whitworth endowment and schools—such as the Owens College, at Manchester—there is in Great Britain the Department of Science and Art, under the Board of Education, with a disbursement of nearly £600,000 per annum. The scope of this department is very large, and embraces schools of science and art, museums, training and technical schools scattered throughout the three kingdoms, with examining functions in thousands of provincial and colonial places, including New Zealand.

I have alluded to the parliamentary definition of technical education. It is defined by "The Technical Instruction Act, 1889," to mean the principles of science and art applicable to industries; the application of special branches of science to specific industries; and a further and rather elastic definition embracing any other forms of instruction, including modern

languages, commercial and agricultural subjects, which may in the opinion of the local authority be required by local circumstances. During about ten years County Councils and other local authorities have administered this Act. A special tax on beer and spirits provides the funds, supplemented in some cases by local grants. In this way two years ago very nearly a million pounds was disbursed. It will be admitted that this is not a large expenditure in a population of forty millions—about 6d. per head, in fact. Probably the whole of the technical education in the United Kingdom does not exceed 1s. per annum per head of population. It must be admitted that this is not likely to effect the desired end if we are to keep—or shall we say regain—our commercial and manufacturing supremacy.

Great and manifold, from a social and literary point of view, are the advantages of a classical education, but by itself it is not on the lines required for the subject in hand. There is an amusing preface by an engineer, the author of a work on bridges which has become a standard. He details his classical education, and the time, trouble, and expense he spent in acquiring a proficiency in the Latin language. And in all his after-experience in his profession he pathetically relates that he found not one instance in which his accomplishment served him for good. But that it should not be always so he entitled his book "De Pontibus," and proudly points to this as one instance in which he has been able to air his Latin in his profession.

I came across some time ago a simile intended to indicate a degree of condescending patronage, a certain supercilious bearing not unmingled with a shade of contempt. It was likened to the bearing of an Oxford don towards an engineering professor in a northern university. This sort of thing, no doubt, has some foundation in fact, and has to be reckoned with. It is hard to get out of a deeply scored groove in conventionalism. I recall an incident in my own experience. I was at one time in the course of my public duties much interested in the subjects prescribed for the Senior Civil Service examinations, in so far as they concerned the admission of cadets into the Public Works Department. I found that Latin was compulsory, while trigonometry or statics was not. Now, Latin was of no manner of use in the Public Works Department, while trigonometry was indispensable. In response to a vigorous protest on my part the subjects were altered to this extent: It was made optional for a candidate to substitute trigonometry for Latin. This practically met the case in point, but it would still allow of a young man permeated with classical lore, but with only the most hazy idea of trigonometry or mechanics, entering a profession where it

is essential that a knowledge of these things should be like a second nature.

Another conventionalism to be reckoned with is the depreciation implied in the comparison of theory and practice. An ounce of practice is said to be equal to a ton, I think it is, of theory. If there is any foundation for this at all it must be infinitesimal. Theory which is held so cheap cannot be theory in fact. By theory I mean scientific deduction, and not hypothesis merely. The three angles of any triangle are in theory equal to 180°, but if in actual measurement they amount to more or less, then practice is wrong. If, however, it is held to be theoretically possible that the angles may be so carefully measured with an instrument so absolutely perfect that they may sum up exactly to the known figure, then practice will show that this theoretical supposition is wrong, and that only by accident can such absolute perfection be attained. An incident in point came under my observation in the Old Country very many years ago. One of the best workmen I ever knew—a foreman fitter—was marking off on a circle the centres of six bolt-holes. As usually happens, the dividers, opened to the radius of the circle, did not, on stepping round, exactly close on the commencing-point. My friend remarked that it never did—that the radius of a circle did not divide the circumference exactly into six, but only very near it. Of course, I said that it was a geometrical fact that such a division was exact, but was met with the remark that it might be so in theory, but practice showed the contrary.

A good many years ago the Messrs. Denny, of Dumbarton, recognised that among the thousands of their workmen there ought to be much latent talent for the invention of improvement in tools and methods of application, only requiring some incentive to bring it into action. The firm accordingly instituted a scheme by which rewards were to be given in proportion to merit for any improvement by which time could be saved or better work performed than was possible with previous appliances. This scheme has proved very successful, and for many years numbers of important improvements of all kinds, large and small, were the result of an incentive to the use of their heads as well as their hands by men who had nothing to learn in mere workmanship.

Among those misguided searchers after perpetual motion, of which we have evidence even to this day, there is not one true mechanic. Either they are workmen more or less expert or mere mathematicians, in neither case with any knowledge of or capacity to acquire true mechanics. I have met several of both classes, and found in all cases their craze incurable. I noticed very lately that a gentle-

man informs the *Winton Record* that after forty years' experimenting he has succeeded in attaining perpetual motion, and protected the invention over the world. It is hard to conceive what sort of intellect could labour for forty years at a mechanical impossibility without discovering it to be so.

But even the primary-school master must be abroad now and then, and I am tempted to give one or two instances of a rather comical nature. I dare say many here present have observed that the terms "square feet" and "feet square" are often used indiscriminately, evidently under the impression that they are synonymous. In a description which appeared lately in a local newspaper of the Duke of Cornwall's apartments on board the "Ophir" the drawing-room was stated to be 1,200 ft. square! Even in these days of big ships this is rather startling, for it means that that room has an area of more than 33 acres; 1,200 square feet, which, of course, was meant, would still indicate a good-sized room at sea, and might mean 40 ft. by 30 ft. Another local paper told us that it is interesting to know that the late Queen's walking-stick was one that had belonged to her "ancestor," King Charles II.

I have taken up more space than I intended when I touched on technical education, but I cannot conclude without mentioning, if I do little more, two or three subjects of economic importance to our community. The first is the drainage of towns and cities, which has always been a subject of first importance; but the recent plague scare brought it more to the front, and showed us unmistakably what a genuine visitation may mean. It is possible that very few could be found who would own to a belief that plague ever entered Auckland, and it is certain that not one would care to deny the importance of being prepared for combat with the pestilence. What such a visitation would mean to Auckland some may know, but not many actually realise. But with our commerce destroyed, and the influx of all visitors—and their money—stopped, together with the stampede of that large section of our residents who are here for the sake of health, all would soon become alive to the reality. And is anything being done to meet such a contingency? Practically nothing, so far as the first requirement—complete and thorough drainage—is concerned. Without that no amount of cleaning of back yards and slums will be of any use. Such measures without perfect drainage only serve to distribute filth over a wider area than it before occupied.

But measures that are sufficient in one town may not be applicable to another. Sydney carries the sewage out to the rock-bound coast of the Tasman Sea. London, after allowing the sewage to settle in tanks, runs the effluent, more or less

clear, into the Thames, and employs a fleet of steamers to carry the sludge practically out to sea. In both cases nature is left to finish the work. It is an axiom in engineering, as it should be in every calling, not to fly in the face of the working of nature, but to assist nature and nature will assist you. So, as there are means provided by which the refuse of the world is turned to good account, we have only to make use of them and the mysterious operations of nature will do the work. The septic treatment of sewage therefore seems to offer to us more prospect of dealing with the drainage of towns which have not the advantage of being able to discharge it into the open sea. Much has been already achieved in this direction, but much remains to be added by experience. Nevertheless, I anticipate that within a very few years the treatment of sewage will be as certain and successful as that of any other process or manufacture.

The utilisation of natural sources of power must always be of importance, and the question seems to be now occupying a good share of attention. Water-power from rivers is usually the first in such schemes, and, in conjunction with long-distance transmission of energy by electrical means, offers a good field; but the scope and results are more restricted than are usually believed. It is very seldom that river rapids or falls can be harnessed into work except at a very large cost, and even where in more favourable cases power can be got in hand cheaply the distance over which it must be conveyed rapidly absorbs the efficiency, and it is wonderful how soon the economy of water-power is overtaken and surpassed by steam-power with all its low efficiency.

The harnessing of the tides is another scheme oftener talked about than practised. There is probably no power in nature at once so vast, so visible, and so difficult to utilise as that of the tides. There are exceptional cases where tidal power has been economically used, but as yet they are very few. It seems to me, however, that much more might be done in this direction, and that there are places where a very considerable amount of energy might be made available by a judicious arrangement of floating wheels, dynamos, and secondary batteries, all under automatic control. The harnessing of wave-power on the sea-coast has been less often proposed, and, with the exception of bell-buoys, still more seldom put in practice. It may be found, however, that there are by this means greater facilities for gathering up and storing energy than by the tides. There appear to be situations peculiarly adapted for such an installation, such as at some breakwaters which have been designed by flying a good deal in the face of nature. At these places I believe the wave-power might be so used that it would effectually keep down

the accumulation of shingle by conveying it beyond the harbour and leaving it free to resume its travel along the coast.

I think it unquestionable that before very long a large amount of power will be generated at our coalfields by the use of slack coal, nearly all of which goes now to waste. Either by the use of steam, or by producer gas, electrical energy could be generated and sent with economy certainly to a distance of about a hundred miles.

Our thermal springs form, I believe, an asset in the capital account of the Auckland Provincial District the value of which it is difficult to estimate, and I am sure this is even now not sufficiently recognised. Looked at from the lowest point of view, the amount of hard cash brought into the country year by year by foreign tourists must amount to a very large sum, so large that it would take an immense area of the finest agricultural lands to produce profits equal to it. I speak in general terms, because I have no data on which to found estimates of tourist expenditure. But, taken on a social and humane basis, the value of the several thermal centres, although more generally recognised, can never be stated in money. It is very satisfactory to observe that the Government seems at last to be fully alive to the importance of fostering the traffic; but very much yet remains to be done in this direction. One essential line of action has never been attempted—I allude to the compilation of an authoritative list of all that can be procured of the very remarkable cures effected during, say, the last twenty years. There is yet time for this; and, now that the tourist traffic has become a branch of a special department of administration, we may hope that it will not be lost sight of. It is now over twenty-three years since I first knew Rotorua, and ever since I have had exceptional opportunities of observation, and have known of many cures of a most startling character. Many of these, no doubt, are on record at the Sanatorium, but numbers of others—indeed, the great majority—were never treated there. The principal cases are, no doubt, well remembered by residents and business people, and a systematic inquiry might easily furnish authentic material, which, compiled and issued under official authority, would carry weight wherever published, which should be the world over.

I have thus endeavoured to enlist your interest in a few subjects of economic importance, and if I have been successful in respect to even one of them in any degree I shall feel more than repaid for the effort.

Art. II.—*On the Senses of Insects.*

By G. V. Hudson.

[*Presidential Address to the Wellington Philosophical Society, delivered 25th June, 1901.*]

The few remarks I propose to offer to-night contain but little original matter, and probably many members will find that they are quite familiar with most of the facts about to be related. My primary object in recounting these observations is, however, to show the large amount of valuable work which may be done by any one who is endowed with a fair amount of leisure, and has a taste for observing natural-history objects. Unlike other branches of entomological field-work, the study of the senses and intelligence of insects can be pursued without the observer leaving his own home, and this, no doubt, will be a recommendation to many whose health, and other considerations perhaps, do not permit of prolonged visits into the wilds of New Zealand.

Observations on senses and habits, &c., do not require that minute and technical knowledge of species and genera the acquisition of which is often regarded as dry and laborious. A few of the commonest and most easily recognised insects will suffice for this class of work, and it is only necessary for the student to know the names of these in order that he may place his observations on record.

I should state that most of the observations here given are taken from the works of Sir John Lubbock (now Lord Avebury), who has done so much to encourage the investigation of living insects, and has so clearly shown that the systematic collection and classification of dead insects is not the whole science of entomology, as some entomologists appear to imagine.

Regarding the senses of insects, there seems to be little doubt that they have in some degree all the senses possessed by man; but in certain cases these senses are considerably modified. There are also some reasons for supposing that insects may be endowed with other senses which we do not possess, and of which we can consequently have no conception. The most primitive of the senses, that of touch, is undoubtedly possessed by insects in a very marked degree. It was formerly supposed to reside chiefly in the antennæ and in the palpi, but more modern investigations tend to show that the sense of touch in insects is chiefly situated in certain special hairs which occur on various parts of the body and appendages. The bases of these hairs penetrate the horny integument of

the insect, and are connected with special nerve-fibres. They are much more numerous on some points of the creature than on others. They occur in very large numbers, for instance, on the proboscis of the common house-fly. The skin of insects is so much harder and more insensible to outside impressions than the covering of most other animals that special tactile organs are necessary, and it appears that these hairs perform the needed function.

The possession of the sense of taste in insects cannot be questioned. No one who has ever watched a bee or a wasp can entertain the slightest doubt on the subject. It is, again, probably by taste that caterpillars recognise their food-plant. Moreover, this is partly the effect of individual experience, for when first hatched caterpillars will often eat leaves which they would not touch when they are older and have become accustomed to a particular kind of food. Special experiments have, moreover, been made by various entomologists, particularly by Forel and Will. Forel mixed morphine and strychnine with some honey which he offered to his ants. Their antennæ gave them no warning. The smell of the honey attracted them and they began to feed; but the moment the honey touched their lips they perceived the fraud. Will tried wasps with alum, placing it where they had been accustomed to be fed with sugar. They fell into the trap and ate some, but soon found out their error, and began assiduously rubbing their mouth-parts to take away the taste.

Will found that glycerine, even if mixed with a large proportion of honey, was avoided, and to quinine they had a great objection. If the distasteful substance is inodorous and mixed in honey the ant or bee commences to feed unsuspiciously, and finds out the trick played on her more or less quickly according to the proportion of the substance and the bitterness or strength of its taste. The delicacy of taste is doubtless greater in bees and ants than in omnivorous flies or in carnivorous insects. At the same time the sense of taste in ants is far from perfect, and they cannot always distinguish injurious substances. Forel found that if he mixed phosphorus in their honey they swallowed it unsuspectingly and were made very unwell. It cannot, then, be doubted that insects possess a sense of taste. The seat of it can hardly be elsewhere than in the mouth or its immediate neighbourhood; and in all the orders of insects there are found on the tongue, the maxillæ, and in the mouth certain minute pits, which are probably the organs of taste. In each pit is a minute hair, or rod, which is probably perforated at the end.

Passing to the sense of smell, we find that there are good reasons for supposing that most insects are well endowed in this respect. The seat of the sense is supposed to be situated

in a number of minute cylinders and pits which are placed on the antennæ and on the palpi. The evidence obtained from experiments is somewhat conflicting as between the antennæ and the palpi; but, if the sense of smell is supposed to reside partly in each of these appendages, the results of the various observations are brought into accord. In connection with this subject the following observation, which I made on the 4th September, 1882, on a specimen of one of our common butterflies (*Vanessa gonerilla*), may be of some interest: At 9 a.m. I placed some moistened sugar in a small china colour-pan about ¼ in. square. The butterfly was rather torpid owing to the low temperature, and I therefore removed it from the cage and placed it on the edge of the vessel containing the sugar. Almost at once it began to uncoil its proboscis, and whilst doing so it steadily elevated and depressed its antennæ, the tips of which frequently touched the sides of the vessel. Sometimes each antenna was elevated and depressed singly; at other times both organs were moved together. These remarkable movements of the antennæ were, I think, merely indicative of the insect's pleasure, and this explanation is supported by the observations of Sir John Lubbock respecting the movements of the antennæ in ants. When the butterfly had completely uncoiled its proboscis it felt all round the vessel with the sensitive extremity of that organ, which certainly appeared to be endowed with the sense of smell. Soon it found the liquid sugar, which it eagerly sucked for about three minutes; and during the whole of this time the butterfly continued to move the antennæ in the manner above described. As soon as the insect ceased feeding, however, the antennæ were restored to their normal position—*i.e.*, almost perpendicular to the main axis of the insect's body. After this I made several very sharp noises—whistling, and ringing on a tumbler—but the butterfly did not appear to hear them, and the antennæ were held perfectly motionless throughout. This experiment appears to indicate, I think, that in butterflies the sense of smell is situated in or near the extremity of the proboscis, and that the sense of hearing is absent or but little developed. I have often tried to frighten butterflies in the field by shouting at them, but have never succeeded in making one of these insects rise from its perch in this way, although the slightest movement on the part of the observer would at once have caused the insect to take flight.

The following are some of the experiments related by Lord Avebury in connection with testing the organs of smelling in insects. He says, "I myself took a large ant (*Formica ligniperda*) and tethered her on a board by a thread. When she was quite quiet I tried her with tuning-

forks, but they did not disturb her in the least. I then approached the feather of a pen very quietly so as almost to touch first one and then the other of the antennæ, which, however, did not move. I then dipped the pen in essence of musk and did the same; the antenna was slowly retracted and drawn quite back. I then repeated the same with the other antenna. I was, of course, careful not to touch the antennæ. I have repeated this experiment with other substances with several ants, and with the same results. Perris also made the same experiments with the palpi, and with the same result; but if the palpi were removed the rest of the mouth gave no indications of perceiving odours."

Graber also made a number of experiments, and found that in some cases (though by no means in all) insects which had been deprived of their antennæ still appeared to possess the sense of smell. But if, as we have, I think, good reason to suppose, the power of smell resides partly in the palpi, this would naturally be the case. He also tested a beetle (*Silpha thoracica*) with oil of rosemary and assafœtida. It showed its perception by a movement in half a second to a second in the case of the oil of rosemary, and rather longer—one second to two seconds—in the case of the assafœtida. He then deprived it of its antennæ, after which it showed its perception of the oil of rosemary in three seconds, on an average of eleven trials; while in no case did it show any indication of perceiving the assafœtida, even in sixty seconds.

This would seem to indicate a further complication—not only that both the antennæ and the palpi may possess the sense of smell, but also that certain odours may be perceived by the former, and others by the latter. As regards flies (*Musca*), Forel removed the wings from some bluebottle flies and placed them near a decaying mole. They immediately walked to it, and began licking it and laying eggs. He then took them away and removed the antennæ, after which, even when placed close to the mole, they did not appear to perceive it.

Plateau also put some food of which cockroaches are fond on a table, and surrounded it with a low circular wall of cardboard. He then put some cockroaches on the table. They evidently scented the food, and made straight for it. He then removed their antennæ, after which as long as they could not see the food they failed to find it, even though they wandered about quite close to it.

On the whole, then, the experiments which have been made seem clearly to prove that in insects the sense of smell resides partly in the antennæ and partly in the palpi. This distribution would be manifestly advantageous. The palpi are more suited for the examination of food, while the an-

tennæ are more conveniently situated for the perception of more distant objects. The remarkable power possessed by the males of many species of moths which enables them to discover a newly emerged female of the same species, even when enclosed in a box situated perhaps a considerable distance from the insect's natural haunts, is well known to collectors; and its truth is sufficiently proved by the very much higher prices charged by dealers in entomological specimens for the female specimens of all such species. This faculty of finding the female at a distance is in all probability resident in the antennæ of the male, which are always very amply pectinated in all those species possessing abilities of the kind. It is not, however, by any means certain that the sense involved is that of scent only. In the mosquitoes, at any rate, it has been practically proved that the ability to discover the location of the female is due to a sense nearly akin to that of hearing, and that this sense is situated in the extensive pectinations of the antennæ possessed by the male of that insect.

In connection with this subject the following ingenious experiment made by Mayer is of interest: He fastened a male mosquito down on a glass slide, and then sounded a series of tuning-forks. With an Ut_4 fork of 512 vibrations per second he found that some of the hairs were thrown into vigorous movement, while others remained nearly stationary. The lower (Ut_3) and higher (Ut_5) harmonics of Ut_4 also caused more vibration than any intermediate notes. These hairs, then, are specially tuned so as to respond to vibrations numbering 512 per second. Other hairs vibrated to other notes, extending through the middle and next higher octave of the piano. Mayer then made large wooden models of these hairs, and, on counting the number of vibrations they made when they were clamped at one end and then drawn on one side, he found that it "coincided with the ratio existing between the numbers of vibrations of the forks to which co-vibrated the fibrils." It is interesting that the hum of the female gnat corresponds nearly to this note, and would consequently set the hairs in vibration. Moreover, those auditory hairs are most affected which are at right angles to the direction from which the sound comes. Hence, from the position of the antennæ and the hairs, a sound will act most intensely if it is directly in front of the head. Suppose, then, a male gnat hears the hum of a female at some little distance. Perhaps the sound affects one antenna more than the other. He turns his head until the two antennæ are equally affected, and is thus able to direct his flight straight towards the female.

The auditory organs of insects, then, are situated, in different insects, in different parts of the body; and there is

strong reason to believe that, even in the same animal, this sensitiveness to sounds is not necessarily confined to one part.

From the above it will be seen that there are good reasons for supposing that the organs of hearing are situated in the antennæ of insects, and there is much to support this view, though modern investigation has revealed the existence of well-developed organs of hearing on other parts of the body. Before relating a few of the experiments which have been made in connection with the power of hearing in insects it will, perhaps, be well to very briefly describe the curious ears which have been discovered on the tibiæ of the anterior legs in many grasshoppers, and which are very well developed and easily seen in the specimens of one of our native wetas, which I have pleasure in exhibiting this evening. The researches of Müller, Siebold, Leydig, Hensen, Graber, and Schmidt conclusively prove that these drum-like organs are veritable ears. In grasshoppers and crickets the auditory organ lies in the tibia of the anterior leg, on both sides of which there is a disc generally more or less oval in form, and differing from the rest of the surface in consisting of a thin, tense, shining membrane, surrounded wholly or partially by a sort of hame or ridge.

If now we examine the interior of the leg, the trachea, or air-tube, will be found to be remarkably modified. Upon entering the tibia it immediately enlarges and divides into two branches, which reunite lower down. To supply air to this wide trachea the corresponding spiracle, or breathing-hole, is considerably enlarged, while in the dumb species it is only of the usual size. The enlarged trachea occupies a considerable part of the tibia, and its wall is closely applied to the tympanum, which thus has air on both sides of it, the open air on the outer the air of the trachea on its inner surface. In fact, the trachea acts like the Eustachian tube in our own ear: it maintains an equilibrium of pressure on each side of the tympanum, and enables it freely to transmit the atmospheric vibrations.

On the 17th January, 1890, I made the following experiment on a female specimen of weta (*Deinacrida megacephala*), an insect possessing well-developed ears on the tibiæ of its anterior legs. 11.20 a.m.: I placed the insect on a board suspended from the ceiling, where no vibrations except those of sound could reach it. First I tried a piano, but insect did not appear to hear either treble or bass notes. Then tried beating a kerosene-tin with an iron rod, but apparently insect could not hear noise except when the sounds were very rapidly made and of loud pitch. At this stage the insect seemed to wake up and put out its antennæ and palpi.

When I ceased making the noises the insect again reposed, but on my resuming it jumped off the board and ran away. The creature appeared alarmed at the sounds. The palpi were spread out whilst it was listening, and the antennæ moved up and down. 11.40 a.m.: Placed insect in a cage, also suspended, and allowed her to settle down. Repeated the loud jarring sounds. The insect started, and then squeezed itself into a corner of the cage as though in great fear. After this it took no further notice although sounds were continued for about half a minute. Five minutes later I repeated the sounds, but no notice was taken of them, and I think that the insect was asleep, as in the first instance. 11.50: Again repeated sounds, very loudly this time. The insect trembled and moved its antennæ, but five flies perched on the string supporting the cage took no notice. The female *D. megacephala* appears to only regard the very discordant sounds made with the kerosene-tin and poker. It does not appear to hear the piano at all. 12 noon: Repeated, with same result; insect started, put out palpi, and moved antennæ. Feel sure that when she does not hear she is asleep.

The following experiments are related by Lord Avebury: "Kirby states that 'once a little moth was reposing upon my window. I made a quiet, not loud but distinct, noise. The antenna nearest to me immediately moved towards me. I repeated the noise at least a dozen times, and it was followed every time by the same motion of that organ, till at length the insect, being alarmed, became more agitated and violent in its motions.' And again, 'I was once observing the motions of an *Apion* (a small weevil) under a pocket microscope. On seeing me it receded. Upon my making a slight but distinct noise its antennæ started. I repeated the noise several times, and invariably with the same effect.'"

Will has made some interesting observations on some of the Longicorn beetles which appear to confirm the view that the antennæ are the organs of hearing. These insects produce a low shrill sound by rubbing together the prothorax and the mesothorax. The posterior edge of the prothorax bears a toothed ridge and the anterior end of the mesothorax a roughened surface, and when these are rubbed together a sound is produced something like that made by rubbing a quill on a fine file. Will took a pair of *Cerambyx* (beetles), and put the female in a box and the male on a table at a distance of about 4 in. They were at first a little restless, but are naturally calm insects, and soon became quiet, resting as usual with the antennæ half extended. The male evidently was not conscious of the presence of the female. Will then touched the female with a long needle and she began to

stridulate. At the first sound the male became restless, extended his antennæ, moving them round and round as if to determine from which direction the sound came, and then marched straight towards the female. Will repeated this experiment many times, and with different individuals, but always with the same result. As the male took no notice of the female until she began to stridulate, it is evident that he was not guided by smell. From the manner in which this *Cerambyx* was obviously made aware of the presence of the female by the sound, Will considered it clearly proved that in this case he was guided by the sense of hearing. Will has also repeated with these insects the experiments Lord Avebury made with ants, bees, and wasps, and found that they took no notice whatever of ordinary noises; but when he imitated their own sounds with a quill and a fine file their attention was excited—they extended their antennæ as before, but evidently perceived the difference, for they appeared alarmed, and endeavoured to escape.

Hicks, in 1859, justly observed that "whoever has observed a tranquilly proceeding Capricorn beetle which is suddenly surprised by a loud sound will have seen how immovably outward it spreads its antennæ, and holds them porrect, as it were, with great attention as long as it listens, and how carefully the insect proceeds in its course when it conceives that no danger threatens it from the unusual noise."

Passing now to the organs of vision in insects, we find no difficulty in exactly locating their position. The eyes of these animals, as is well known, are of two distinct kinds—Firstly, the compound eyes, which are made up of an immense assemblage of minute hexagonal eyes usually collected into two large hemispheres situated on each side of the insect's head; secondly, simple eyes, or ocelli, of which there are a variable number usually situated on the top of the head. The compound eyes are present in almost all fully developed insects, but the ocelli are very frequently absent. In insect larvæ and in spiders ocelli are the only organs of sight.

With regard to the actual power of vision possessed by insects little is known with certainty at present. There is no doubt that some species see much better than others. I remember specially noticing this when the European blowfly (*Calliphora erythrocephala*) first appeared in New Zealand during 1888. At that time both the native and introduced species were to be seen resting on fences in the Wellington Botanical Gardens. I experienced considerable difficulty in capturing the European species, owing to its great agility, but could capture the native insect with comparative ease. This circumstance was undoubtedly due to the superior power

of vision possessed by the European insect. I afterwards proved this by experiment. When a number of both insects were resting close together I would gradually move my hand towards them, and I noticed that the introduced blowflies invariably saw my hand and took wing before the native species. I verified this by numerous experiments and always obtained the same results.

Ordinary observation in the field proves that some insects undoubtedly have very keen sight, and almost every one must have noticed that dragon-flies and butterflies are especially well endowed in this respect.

Another interesting question in connection with the vision of insects is the relative functions of the simple and compound eyes. A large number of experiments have been made, and it appears probable that the ocelli are useful in dark places and for near vision. Lord Avebury adds: "Whatever the special function of the ocelli may be, it seems clear that they must see in the same manner as our eyes do—that is to say, the image must be reversed. On the other hand, in the case of the compound eyes it seems probable that the vision is direct, and the difficulty of accounting for the existence in the same animal of two such different kinds of eyes is certainly enhanced by the fact that, as it would seem, the image given by the medial eyes is reversed, while that of the lateral ones is direct."

The modern theories of the evolution of flowers through the agency of insect visitors is now very generally accepted amongst naturalists, but it is obvious that these ideas would be effectually disproved if it could be demonstrated that insects were unable to distinguish colours. The following experiments conducted by Lord Avebury prove, I think, that bees, at any rate, possess the faculty of distinguishing colours: "I brought a bee to some honey which I placed on a slip of glass laid on blue paper, and about 3 ft. off I placed a similar drop of honey on orange paper. With a drop of honey before her a bee takes two or three minutes to fill herself, then flies away, stores up the honey, and returns for more. My hives were about 200 yards from the window, and the bees were absent about three minutes, or even less. When working quietly they fly very quickly, and the actual journeys to and fro did not take more than a few seconds. After the bee had returned twice I transposed the papers; but she returned to the honey on the blue paper. I allowed her to continue this for some time, and then again transposed the papers. She returned to the old spot and was just going to alight when she observed the change of colour, pulled herself up, and without a moment's hesitation darted off to the blue. No one who saw her at that moment

could have the slightest doubt about her perceiving the difference between the two colours. I also made a number of similar observations with red, yellow, green, and white."

The remarkable power which many animals have of finding their way back after having been carried a long distance from home has been explained by some persons as due to a special faculty which has been termed a "sense of direction." In connection with this subject M. Fabre made a number of interesting and amusing experiments. "He took ten bees belonging to the genus *Chalicodoma*, marked them on the back with a spot of white, and put them in a bag. He then carried them half a kilometre in one direction, stopping at a point where an old cross stands by the wayside, and whirled the bag rapidly round his head. While he was doing so a good woman came by, who was not a little surprised to find the professor standing in front of the old cross solemnly whirling a bag round his head, and, M. Fabre fears, strongly suspected him of some satanic practice. However this may be, M. Fabre, having sufficiently whirled his bees, started off back in the opposite direction, and carried his prisoners to a distance from their home of three kilometres. Here he again whirled them round and let them go one by one. They made one or two turns round him, and then flew off in the direction of home. In the meanwhile his daughter Antonia was on the watch. The first bee did the mile and three-quarters in a quarter of an hour. Some hours after two more returned; the other seven did not reappear. The next day he repeated this experiment with ten other bees; the first returned in five minutes, and two more in about an hour. In this case again seven out of ten failed to find their way home. In another experiment he took forty-nine bees. When let out a few started wrong, but he says that, 'while the rapidity of the flight allows me to recognise the direction followed,' the great majority flew homewards. The first arrived in fifteen minutes. In an hour and a half eleven had returned, in five hours six more, making seventeen out of forty-nine. Again, he experimented with twenty, of which seven found their way home. In the next experiment he took the bees rather further—to a distance of about two miles and a quarter. In an hour and a half two had returned, in three hours and a half seven more; total, nine out of forty. Lastly, he took thirty bees. Fifteen, marked rose, he took by a roundabout route of over five miles; the other fifteen, marked blue, he sent straight to the rendezvous, about a mile and a half from home. All the thirty were let out at noon; by 5 in the evening seven 'rose' bees and six 'blue' bees had returned, so that the long detour had made no appreciable difference. These experiments seem to M. Fabre conclusive. The

demonstration is sufficient. Neither the bewildering movements of a rotation like I have described; neither the obstacle of hillocks to pass over and of woods to cross; neither the snares of a track which starts, goes back, and comes again by a very circuitous way can confuse the *Chalicodomas* on their homeward way and hinder them from coming back to the nest." When these experiments are summarised, however, it appears that only forty-seven bees out of 144 actually found their way home, which is a very small proportion when the question of a special unerring instinct is involved.

The following experiment, conducted by the late Mr. Romanes, conclusively proves that it is by sight, and sight alone, that bees find their way home: "In connection," he says, "with Sir John Lubbock's paper at the British Association, in which this subject is treated, it is perhaps worth while to describe some experiments which I made last year. The question to be answered is whether bees find their way home merely by their knowledge of land-marks, or by means of some mysterious faculty usually termed a 'sense of direction.' The ordinary impression appears to have been that they do so in virtue of some such sense, and are therefore independent of any special knowledge of the district in which they may be suddenly liberated; and, as Sir John observes, this impression was corroborated by the experiments of M. Fabre. The conclusions drawn from these experiments, however, appeared to me, as they appeared to Sir John, unwarranted by the facts, and therefore, like him, I repeated them, with certain variations. In the result I satisfied myself that the bees depend entirely upon their special knowledge of the district or land-marks, and it is because my experiments thus fully corroborate those which were made by Sir John that it now occurs to me to publish them. The house where I conducted the observations is situated several hundred yards from the coast, with flower-gardens on each side and lawns between the house and the sea. Therefore bees starting from the house would find their honey on either side of it, while the lawns in front would be rarely or never visited, being themselves barren of honey and leading only to the sea. Such being the geographical conditions, I placed a hive of bees in one of the front rooms on the basement of the house. When the bees became thoroughly well acquainted with their new quarters by flying in and out of the open window for a fortnight I began the experiments. The *modus operandi* consisted in closing the window after dark when all the bees were in their hive, and also slipping a glass shutter in front of the hive-door, so that all the bees were doubly imprisoned. Next morning I slightly raised the glass shutter, thus enabling

any desired number of bees to escape. When the desired number had escaped the glass shutter was again closed, and all the liberated bees were caught as they buzzed about the inside of the shut window. These bees were then counted into a box, the window of the room opened, and a card well smeared over with birdlime placed upon the threshold of the beehive, or just in front of the closed glass shutter. The object of all these arrangements was to obviate the necessity of marking the bees, and so to enable me not merely to experiment with ease upon any number of individuals that I might desire, but also to feel confident that no one individual could return to the hive unnoticed; for whenever a bee returned it was certain to become entangled in the birdlime, and whenever I found a bee so entangled I was certain it was one I had taken from the hive, as there were no other hives in the neighbourhood. Such being the method, I began by taking a score of bees in the box out to sea, where there could be no land-marks to guide the insects home. Had any of these insects returned, I should next have taken another score out to sea (after an interval of several days so as to be sure that the first lot had become permanently lost), and then before liberating them have rotated the box in a sling for a considerable time, in order to see whether this would have confused their sense of direction. But as none of the bees returned after the first experiment it was clearly needless to proceed to the second. Accordingly I liberated the next lot of bees on the sea-shore; and as none of these returned I liberated another lot on the lawn between the shore and the house. I was somewhat surprised to find that neither did any of these return, although the distance from the lawn to the hive was not above 200 yards. Lastly, I liberated bees in different parts of the flower-garden, and these I always found stuck upon the birdlime within a few minutes of their liberation; indeed, they often arrived before I had had time to run from the place where I had liberated them to the hive. Now, as the garden was a large one, many of these bees had to fly a greater distance in order to reach the hive than was the case with their lost sisters upon the lawn, and therefore I could have no doubt that their uniform success in finding their way home so immediately was due to their special knowledge of the flower-garden, and not to any general sense of direction. I may add that, while in Germany a few weeks ago, I tried on several species of ant the same experiments as Sir John Lubbock describes in his paper as having been tried by him upon English species, and here also I obtained identical results—in all cases the ants were hopelessly lost if liberated more than a moderate distance from their nest." Mr. Romanes's experiments, therefore, as he

himself says, entirely confirm the opinion Lord Avebury expressed—that there is not sufficient evidence among insects of anything which can justly be called a "sense of direction."

In conclusion, I should like to allude to the very remarkable discovery made by Lord Avebury some years ago in connection with the limits of vision in ants—*i.e.*, the power possessed by those insects of perceiving the ultra-violet rays of the spectrum, which are invisible to human eyes. This fact was elicited by means of a very exhaustive series of experiments, during which the ants were placed under variously coloured glasses, and also under two distinct, though exactly similarly coloured, chemical solutions, one of which intercepted the ultra-violet rays, whilst the other allowed these invisible rays to pass through it. The results of these numerous experiments are very conclusive, and are recounted at length in Lord Avebury's delightful book on "Ants, Bees, and Wasps." I will not now repeat the details of these experiments, but the following general reflections suggested by this discovery are of more than passing interest, and may well conclude this address: "Again, it has been shown that animals hear sounds which are beyond the range of our hearing, and that they can perceive the ultra-violet rays, which are invisible to our eyes. Now, as every ray of homogeneous light, which we can perceive at all, appears to us as a distinct colour, it becomes probable that these ultra-violet rays must make themselves apparent to the ants as a distinct and separate colour (of which we can form no idea), but as different from the rest as red is from yellow or green from violet. The question also arises whether white light to these insects would differ from our white light in containing this additional colour. At any rate, as few of the colours in nature are pure, but almost all arise from the combination of rays of different wavelengths, and as in such cases the visible resultant would be composed not only of the rays we see, but of these and the ultra-violet, it would appear that the colours of objects and the general aspect of nature must present to animals a very different appearance from what it does to us.

"These considerations cannot but raise the reflection how different the world may—I was going to say must—appear to other animals from what it does to us. Sound is the sensation produced on us when the vibrations of the air strike on the drum of our ear. When they are few the sound is deep; as they increase in number it becomes shriller and shriller; but when they reach forty thousand in a second they cease to be audible. Light is the effect produced on us when waves of light strike on the eye. When four hundred millions of millions of vibrations of ether strike the retina in a second they produce red, and as the number increases the colour

passes into orange, then yellow, green, blue, and violet. But between forty thousand vibrations in a second and four hundred millions of millions we have no organ of sense capable of receiving the impression. Yet between these limits any number of sensations may exist. We have five senses, and sometimes fancy that no others are possible. But it is obvious that we cannot measure the infinite by our own narrow limitations.

"Moreover, looking at the question from the other side, we find in animals complex organs of sense richly supplied with nerves, but the function of which we are as yet powerless to explain. There may be fifty other senses as different from ours as sound is from sight; and even within the boundaries of our own senses there may be endless sounds which we cannot hear, and colours, as different as red from green, of which we have no conception. These and a thousand other questions remain for solution. The familiar world which surrounds us may be a totally different place to other animals. To them it may be full of music which we cannot hear, of colour which we cannot see, of sensations which we cannot conceive. To place stuffed birds and beasts in glass cases, to arrange insects in cabinets and dry plants in drawers, is merely the drudgery and preliminary of study; to watch their habits, to understand their relations to one another, to study their instincts and intelligence, to ascertain their adaptations and their relations to the forces of nature, to realise what the world appears to them—these constitute, as it seems to me at least, the true interest of natural history, and may even give us the clue to senses and perceptions of which at present we have no conception."

ART. III.—*Notes on the Comet of April, May, and June, 1901.*

By G. V. HUDSON.

[*Read before the Wellington Philosophical Society, 25th June, 1901.*]

Plate I.

MY wife and I simultaneously saw this comet from Karori on the morning of the 25th April, at 5.25 a.m. It was then rising behind the eastern ranges, and was sufficiently bright to be conspicuous as a distinct streak of light through some light cirrus cloud in the sky at the time. At about 5.40 it rose clear of the cirrus, and its brightness was so great that I was much surprised that it had not been reported as previously observed. A cablegram announcing that it had been seen in

New South Wales the same morning—though, of course, some two hours later—was, however, received during the day.

Bad weather prevented further observations until Sunday morning, the 28th April, when the comet was visible for a few minutes only, owing to its close proximity to the sun. It rose about 5.53 a.m., and was overpowered by the daylight at 6.10 a.m. Unfortunately, my observatory is so situated that I could not reach it so low in the heavens, and, although I carefully swept for it between 7 and 8 a.m., I did not succeed in finding it. Judging from the view I had of the planet Mercury, I am disposed to think that the comet might have been seen with my 3¼ in. telescope at that hour, as the morning was extremely clear and bright. I next saw the comet on Tuesday, the 30th April, at 5.40 p.m. My point of observation was the main road across the Kelburne Estate. At this time the comet appeared about as bright as Mercury; the tail was indistinct, owing to the strong daylight. As it set ten minutes after I first saw it, I was unable to get home to my telescope.

The next evening—Wednesday, the 1st May—I had the first satisfactory view of the comet through the telescope. The nucleus was very bright, comparatively distinct, and somewhat bean-shaped. The coma was some distance in front of it, and swept round on either side, flowing away behind the nucleus and forming two very distinct tails. There was little change on Thursday, the 2nd May. On Friday, the 3rd May, some traces of the long, faint southern tail, which afterwards became such a remarkable feature of this comet, were first seen, but not clearly until Sunday. Whilst the tails were increasing in length and brightness the nucleus declined in size, brilliancy, and distinctness. The coma appeared to be gradually swept back, until on Tuesday, the 7th, the nucleus was entirely in front of it. By this time I think the comet was beginning to decrease in brilliancy, though the disappearance of the moon during the early evening of Monday, the 6th, rendered it difficult to make any reliable comparisons with previous observations. I was, however, in the habit of noticing what stars could be seen when the comet first became visible in the evening twilight, and, from these comparative observations, I am confident that the nucleus, at any rate, considerably decreased in brilliancy before the 6th May. This, I may mention, was the first evening without the moon, and it is therefore probable that the comet would have been seen to much greater advantage had the evenings been dark during the first week of its appearance in the evening sky. The two sketches (Plate I.) which accompany these notes were made on the evening of the 6th May. One is a telescopic view of the head, and the other an attempt to show the comet as it appeared to the naked eye.

The 9th, 10th, and 11th May were cloudy, and on the 12th, when the comet was again seen, with its tail straight along the belt of Orion, a very great decrease in brilliancy had taken place. Beyond a further steady decrease I did not observe any noteworthy features during the succeeding week; but several other observers remarked to me that the space between the long, faint southern tail and the two brilliant northern tails appeared to be filled in with cometary matter of extreme tenuity.

From this period to the final disappearance of the comet in my telescope on the 15th June there is nothing special to note, except, perhaps, that after about the 20th May the nucleus became slightly brighter in relation to the tail, though, of course, the entire object was continually becoming fainter.

The following rough positions of the comet, taken on the dates stated, will enable amateur astronomers, who are interested, to mark out the track it followed through the constellations during the period I observed it. They were taken with an equatorial telescope of only $3\frac{1}{4}$ in. aperture, and are merely rough approximations. The right ascensions are probably correct within about one minute of time, and the declinations within ten minutes of arc. I have inserted them as they may be of some interest to other amateur observers, and it is also, perhaps, possible they may be of some little use to professional astronomers in estimating the probable orbit of the comet:—

	Right Ascension. H. m.	Declination. ° ′		Right Ascension. H. m.	Declination. ° ′
April 25	.. 1 22	4 0 N.	May 15	.. 5 33	3 35 N.
May 1	.. 3 07	0 30 S.	„ 16	.. 5 40	4 0 N.
„ 2	.. 3 22	0 45 S.	„ 17	.. 5 45	4 20 N.
„ 3	.. 3 38	0 30 S.	„ 19	.. 5 57	4 55 N.
„ 4	.. 3 50	0 20 S.	„ 20	.. 5 59	5 15 N.
„ 5	.. 4 0	0 05 S.	„ 22	.. 6 8	5 45 N.
„ 6	.. 4 14	0 10 N.	„ 23	.. 6 13	6 10 N.
„ 7	.. 4 25	0 35 N.	„ 24	.. 6 18	6 20 N.
„ 8	.. 4 38	1 0 N.	„ 25	.. 6 23	6 30 N.
„ 12	.. 5 11	2 30 N.	June 9	.. 7 03	9 0 N.
„ 13	.. 5 20	2 55 N.	„ 10	.. 7 06	9 15 N.
„ 14	.. 5 28	3 15 N.	„ 15	.. 7 12	9 40 N.

Art. IV. — *The Diversions of the Whare Tapere: Some Account of the various Games, Amusements, and Trials of Skill practised by the Maori in Former Times.*

By Elsdon Best.

[*Read before the Auckland Institute, 7th October, 1901.*]

"*Ka kawea tatou e te rehia*" (We are allured by the arts of pleasure).

Among races not possessing a written language and literature it is not surprising to find that great prominence is given to games and amusements of various kinds, more especially to those which would serve to while away the hours of darkness.

The Maori people of this land, although possessing no graphic system prior to the arrival of Europeans, had, nevertheless, a most extensive collection of ancient sagas, songs, history, folk and other lore retained by their wondrous memories, and thus handed down orally from one generation to another. Such knowledge was most extensively drawn upon during winter evenings or inclement weather for the amusement of the people. They possessed, moreover, a great liking for amusements in the form of games, dancing, toys, and, as we have said, story-telling. As little has been placed on record anent such matters, I propose to bring together in this article such notes under the above heading as have been collected from the Tuhoe Tribe of natives. It is therefore safe to say that this article will be by no means an exhaustive one, and will but serve to give an idea of what forms of games, &c., were indulged in by the denizens of Tuhoeland in pre-*pakeha* days. Such amusements would be described by the modern Maori as "*ahuareka*," but in the days of yore they were described by the term "*rehia*," and "*Nga mahi a te rehia*" meant "the art of pleasure."

THE WHARE TAPERE.

The *whare tapere* was a house where the young people of a fort or village would gather at night in order to amuse themselves in various ways—*i.e.*, with singing, dancing, playing of games, &c. It was the play-house of the neolithic Maori, and doubtless the prototype of the modern theatre of the intrusive *pakeha* (Europeans). It was not necessary that a village should have a house set aside or used specially for amusement. Such terms as "*whare tapere*," "*whare potae*," "*whare pora*," &c., are to a great extent mere figures of speech. Still all amusements are spoken of as the arts of the *whare tapere*—*i.e.*, the art of pleasure.

In this article I propose to deal not only with such forms of amusement as pertained to the *whare tapere*, but also to pass out from that edifice in order to mention certain outdoor games of past generations; for of all the ancient games of Maoriland but few have survived, and those few are not as the men of old knew them: the trail of the *pakeha* is over them all.

THE PERSONIFICATION OF PLEASURE.

Kant speaks of the category of causality as being a necessary form of pure reason. It is highly improbable that the ancient Maori had perused the works of the latter-day Teutonic philosopher. There are a few chronological and other reasons against such an assumption. And although his primitive intellect has ever felt that causality exists, yet he would but know it in an abstract form—that is to say, as a law of thought. That half-knowledge, however, prompted his crude mental powers to seek not the true cause of things, but the agency by which they were presented to his sight, hearing, or understanding. Thus the ancient Maori had, after how many centuries of groping through the gloom, personified almost everything that came under his notice. His limited mentality sought an agent for all things, and that agent was invariably presented to his vision in human form. Thus in the extensive and wondrous Maori mythology we find personifications—*i.e.*, anthropomorphous agents—which represent war, peace, disease, the sky, the earth, the sun, moon, and stars, meteors, rainbows, fire, water, fish, birds, trees, heat, the seasons, death, &c.

In like manner are the arts of carving, weaving, &c., supplied with such personifications, and a myth of a similar nature is attached to the art of pleasure. Games and amusements have their mythic agent or tutelary deity, to whom is attributed their invention. Among the majority of Maori tribes this personification or agent is Rau-kata-uri, a name often coupled with that of Rau-kata-mea. To these are attributed flute-playing and games of amusement. Among the Tuhoe Tribe, however, the places of the above are taken by Marere-o-tonga and Takataka-putea. These two mythical beings were, to the Child of Tamatea,* the origin and personification of *nga mahi a te rehia*—the art of pleasure. The names of many such personifications, &c., differ among the Tuhoe Tribe, which may be explained by the fact that among these people are preserved the purest versions of the myths, rites, and legends of the original migration of Polynesians to this land, a migration that probably emanated from the

* The Child of Tamatea: A term applied to the Tuhoe Tribe.

western Pacific, whereas the latter migration came from the far east.

It should be here remarked that these personifications or tutelary genii are not termed "gods" (*atua*) by the Maori, but merely "parents" or "origins." In like manner the rendering of the word "*atua*" by the term "god" is objectionable; "demon" is more acceptable.

The following is a genealogy of Takataka-putea and Marere-o-tonga, although certain traditions place them much further back. It is well to note here that the Maori looks upon most of the singular personifications of Polynesian mythology as ancestors of man, and traces his descent from many of them, as, indeed, he does from the sky, the earth, the heavenly bodies, &c.:—

Rangi-whakere
Wao-nui
Wao-roa
Wao-wheneke
Te Umuhanga
Haehae
Tane-hikapua
Rongo-i-te-ata
Takataka-putea
Marere-o-tonga
Puhao-rangi
Oho-mai-rangi
Mutu-rangi
Manawa-tu
Manawa-rere
Manawa-oho
Manawa-kotokoto
Whare-nui
Whare-roa
Whare-manahanaha
Hana
Tangi-haruru
Hui
Ruru
Katau
Tawake-hore
Te Pupara
Whare-koiwi
Hine-haere
Te Putu
Taupo
Tamaku — Ripeka.
Turu — Takurua.
Mihi
(Ngati-whare Tribe).

In White's "Ancient History of the Maori," vol. iii., page 23, is the following sentence: "Nukutere was the vessel of Whiro-nui, ancestor of Porou-rangi, and of his wife Arai-

ara. The wise men (*tohunga*) of that vessel were Takataka-putea and Marere-o-tonga." Again, at page 7 is the following: "Uenuku asked, 'O, Whena! Where are our children?' And Whena replied, 'They are allured by pleasure (*rehia*). They are enjoying the arts of their ancestors, of Takataka-putea and Marere-o-tonga.'" In Shortland's "Maori Religion," page 17, these two are said to be twins, and the offspring of Papa-tuanuku, or Mother Earth.

Takataka-putea is the name of one of the nights of the moon, either the last or one of the last. When the moon dies then the wise men say, "Takataka-putea is in the hole (abyss or space) rolling about."

The following fragment of mythological lore, preserved by Ngati-awa, places this pair far back in the night of time: "When Rongo was defeated by Tu-mata-uenga he went to the *whare patahi*, to Marere-o-tonga and Timu-whakairia, to fetch the *wananga* to seek for peace. The *wananga* brought to this land (New Zealand) was the *wananga* of witchcraft. It was brought on Takitumu." The *whare patahi* appears to have been some sacred place or receptacle for sacred things. "*Wananga*" is a difficult word to define the meaning of. Meanings thereof given to me are—(1) A priest or seer; (2) a receptacle for sacred things; (3) a medium, as of a god; (4) (as a verb) to recite, as a genealogy, or declaim, as in reviling a person. In Paumotuan "*vananga*" means "to warn by advice, counsel; to discourse." Hawaiian *wanana*, "to prophesy." In Mangarevan *vananga* is "a herald, an orator, a prayer"; as a verb, "to name again and again," &c.; while *etua-vananga* means "a war-chief." *Wanawana* in Maori (New Zealand) means "spines, bristles, rays," &c.

The *whare patahi* was probably some form of primitive temple or repository, material or imaginary. Possibly it may have been the ancient prototype of the *whata puaroa*. The following fragment seems to denote that it was a sort of temple of peace, or talisman:—

Te whare patahi
E hui te rongo,
E hui te rongo,
E puta mai ki waho.

The following song was sung when peace was desired or about to be cemented. Tuhoe say that it was composed by Te Turuki (Te Kooti of infamous memory), but it bears an ancient impress:—

E mahi ana ano a Tu raua ko Rongo
I ta raua māra, koia Pohutukawa
Ka patua tenei, koia moenga kura
Ka patua tetahi, koia moenga toto
Na raua ano ka he i te rir

Ka tikina ki raro ra
Kia Marere-o-tonga, kia Timu-whakairia
E ora ana te wananga—e
Mauria mai nei ko te rongo-a-whare
Ko te rongo-taketake
Ki mua ki te atua
Ka whakaoti te riri—e.

The following song is very old, and refers to the period of the Maori sojourn in Rarotonga, about five hundred years ago. It contains references to a well-known incident in Maori history, and also mentions the name of Marere-o-tonga :—

Noho noa whati tata, haereere noa ra te takutai
Kua pono ano ki te iwi no paraoa
Mauria mai nei hai heru 'tahi taha
Hai patu 'tahi taha
Manaakitia mai nei e Uenuku
Tae noa mai nei kua he te iringa o te heru
Me ui ra ki te poupou o te whare,
Kaore te ki mai te waha
Me ui ra ki te tuarongo o te whare,
Kaore te ki mai te waha
Me ui ra ki te tiki nei, kia Kahutia-te-rangi
Kai hea taku heru?
Tena ka riro i te tahae poriro tiraumoko nei
Moenga-hau nei, moenga raukawakawa nei.
Ka mate tera i te whakama
Ka hiko ki tona waka
Kia Tu-te-pewa-a-rangi nei
Ka hoe ki waho ki te moana
Ka unuhia te koremu
Ka mate i reira Epipi, ka mate i reira Tahau
Ka mate i reira te ara o Tu-mahina nei
Matariki ka* kau i te ata nei—e
Tena a Ruatapu kai te whakakau
I te moana e takoto nei—e
Te hinga nei—e. Te wharenga nei—e
Te marara nei—e
Pokia iho ra te Puke ki Hikurangi
Tutu noa ana Marere-o-tonga kia mau.

Hamiora Pio, of the Children of Awa, says, "Rongo visited Marere-o-tonga and Timu-whakairia. When Rongo returned from his visit to the heavens he saw Marere-o-tonga blocking up a cave to enclose him in. Then Rongo slew Marere-o-tonga, who may be seen by looking up into space—he is suspended from the heavens."

But the door of the *whare tapere* is open. The young people of the year 400 *Anno Toi* are collected therein, and the games and amusements of old are in full swing. We will enter and seat ourselves on the right-hand side, against the wall. We are looking upon the young people of that date, clothed simply in kilt or girdle, and collected in picturesque

* Or *kakau*, a star.

groups. We stay time and roll back the years that you may see the amusements of the Children of Toi, the arts of the *whare tapere—nga mahi a te rehia, a te harakoa*—the arts of pleasure and of joy. We produce the modern notebook. *Ka kawea tatou e te rehia :—*

HAKA : POSTURE DANCES.

The *haka* was the most general and popular form of amusement in the *whare tapere* of old, and it is one of the few that have survived the advent of the white man. There were, and still are, many different forms of *haka*, some of which, as the *haka koiri*, are now obsolete, and many show traces of European influence. They are interesting to onlookers inasmuch as the performers keep such remarkably good time in the various movements. And such movements are many; the limbs, head, hips, and body are all subjected to various flourishing, swaying, or quivering motions, many of a dædalian nature and none awkward or uncouth, but graceful and pleasing to the eye.

Haka are composed in honour of a distinguished guest or important personage, to satirise or show approval of some individual or tribal act, or to deride and belittle an enemy. The latter, however, is probably more properly termed a "*ngeri*."

New *haka* are often composed, even in these degenerate times, on the lines given above.

The following fragment will explain the way of rendering a *haka* :—

The fugleman (solus) : "A-a-a-a-a-a ! He ringa pakia."
[Here all players begin to strike their hands on their thighs, in time.]
Fugleman: "I ki mai nga iwi o te motu nei ma te rohe potae au ka mate."
Chorus : "Kaore !"
Fugleman : "I ki mai nga iwi o te motu nei ma te rohe potae au au ka mate."
Chorus: "Kaore ! Kaore !"
All continue: "Ma (mea tangata), he aha ! Ma (mea tangata), he aha ! Ma Timi Kara e whakawhaiti," &c.

The origin of the *haka* is, so say the Maori, the *haka a Raumati* (the dancing of Raumati, the personification of summer). This term is applied to the quivering appearance of heated air as seen on a hot day. Another name for it is *te haka a Tane-rore*, the latter being the offspring of summer. In the ancient Maori mythology Te Ra (the sun) married Raumati (summer), their offspring being Tane-rore, the quivering heat. When Ruaumoko (god or demon of the underworld and originator of earthquakes) pulls the cords that move the

earth, then the *haka a Tane-rore* is seen. The following is the *haka* of Raumati:—

E whiti te ra, paroro ki te kiri
Ka haramai koe, ka ruru i aku iwi
I te hinapouri kerekere
I taia iho nei ki raro ra i au e
Pai aha ha!

The following is the original *haka*, the first one known in the world:—

Aue! Te ra, te whetu, ka rere mai i te pae
Ko Kopu koia kapokapo mai e i te tautara
Kia aurora i au e.

If in summer-time you look upwards you will see the *haka* of Raumati flashing and twinkling in space. That is the origin of the *haka* of the world.

The following is an old-time *haka*:—

Ka tito au, ka tito au, ka tito au, kia Kupe
Te tangata nana i hoehoe te moana
Tu ke a Kapiti, tu ke Māna, tu ke Aropawa
Ko nga tohu tena a taku tupuna a Kupe
Nana i whakatomene Titapua
Ka toreke ia te whenua—e.

When performing *haka* the performers always vie with each other as to who shall give the best rendering, and many traditions are extant as to young women being captivated by the grace of movement displayed by men in these dances. For the *whare tapere* was the place where the young people met together in former times to pass the evening in various amusements, after the labours of the day were over. Elderly people would also be present, and some of them would take part in games or *haka*. I have seen an old native of seventy unable to resist the fascinations of a *haka*, and throw off his blanket and join in.

The words of a *haka* are either sung by all the performers, or, in some cases, the fugleman leads off for a line or two and the others join in as a kind of chorus, as we have shown. The term "*haka*" is applied to both the dance and the song which accompanies it. The time for the various motions appears to be taken from the song.

The following *haka* is one of a type known as a *manawa wera*, which were sung and danced on the return of an unsuccessful war-party. As the defeated warriors marched into the village home they were met by a band of people, principally women, dressed in old disreputable garments (the sackcloth and ashes of the Maori), who pranced before them and indulged in those violent energetic movements termed "*whākapi*" or "*pikari*," the emitting of most distressing grunts, and the exhibiting of the whites of the eyes. They would

perform and sing the *haka*, which, with the above performances, denoted grief for those slain and anger against the hapless who had lost the day and returned alive. Such is the *manawa wera*, or seared heart.

Te kotiritiri, te kotaratara, o tai, o huki, o hope—e
Whakatitaha rawa te waha o te kupenga ki uta
Kia tairi—a-ha-ha!
Hoki mai, hoki mai—e
Kia kawea koe ki tera whenua
Ki era tangata,
Nana i ki mai
Uhi! Uhi!—e-e
A—ha-ha!

Another class of *haka* are those repeated while playing certain games, as we shall see anon. Others, again, are juvenile jingles repeated by children for their own amusement. The following are samples of such:—

1.

No wai te waka e rere i waho i te moana
No Kari-momona te wawata tiko tata.

2.

Tikina kotatia te waka o nga tamariki
Kai te hoko titi, kai te hoko tata
E ka poroporo mai hoki
Te poro ki to tehe.

3.

Po kaka, tahuna mai he rama
Kia marama a Pipora tatutatu na
Tăkĕrĕ! Takere! Takere!

The following are specimens of mŏdern *haka*. They were composed and sung, with the usual wild gestures, by the Tuhoe Tribe when the Land Commission first sat at Te Whaiti and the long battle commenced for the possession of that land:—

Te tangi mai a te ika nei, a te *poraka*
Ku-ke-ke—e!
Ku-keke-keke a Tuhoe ki Te Whaiti!
Kai a Raharuhi te paenga mai o te ure putete
Te huruhuru a e apu ra i te kirikiri tai—e-ha!
Titiro ki runga! titiro ki raro!
Titiro ki te mana motuhake e rere mai nei—e!
Hihi ana mai te *pene* a te *Komihana!*
A hihi ana mai! Aue!

In the above Tuhoe compare their descent on Te Whaiti, in order to establish claims by conquest and *mana*, with the appearance and rapid increase of the frog, which has only of late reached these parts. In the sixth and seventh lines they call upon their old-time serfs to look up and gaze upon the flag of Tuhoeland, across which runs the legend: "*Te mana motuhake mo Tuhoe*" (The special *mana* for the Tuhoe Tribe).

Homai aku kura
Naku ano aku *Komihana* i tiki
Ki te puna o Poneke heri mai ai
Titiro ki raro! titiro ki runga!
Titiro kia Matariki!
Titiro! Titiro! Titiro!

The Poi.

The *poi* may be said to be allied to the *haka*, and is so styled by the natives. The *poi* dance (so termed) is performed by females. Each performer has a small, light ball made of leaves of the raupo tightly rolled, and having a string attached to it. In times past these *poi* balls were ornamented by attaching the long hair from the tail of the Maori dog, now extinct. The players hold the string, and, timing each movement to the *poi* song (*rangi poi*), twirl the light balls in many directions—now in front of the body, now over the right shoulder, then the left, &c. The players stand in ranks while performing. One of these time songs commences thus:—

Kia rite! kia rite! kia rite!
Kokiri kai waho, &c.

Here the words "*kia rite*" mean "keep time," and the players take their time from the words, the movement of the ball changing at the second line. This game has been revived of late years, and was one of the attractions of the Maori meeting at Rotorua at the time of the visit of our Royal guests in June, 1901. We give below some of the old *poi* time songs as sung or chaunted during the game.

The following was used both as a *rangi poi* and as an *oriori*, or lullaby. It was composed by one Hine-i-turama to sing to her child, which same child was in the form of a stone, and which that estimable woman used to nurse and sing to —a by no means uncommon thing among childless native women. It reminds one of the Dutch sooterkin:—

E noho ana ano i tona taumata i Tihei
E papaki kau ana te paihau o te manu
Kei tata mai ki taku taha
E poi ana te tara i raro
Kia riro mai taku ipu kai ra
Ko Te Heuheu, i whakatapua ki te aha te hau tapa
Tikapo au anake e kai nei i te roro o Takeke
Kai atu, whakairihia ki te patanga (pataka)
Kai atu patanga, ko te kai ra i korongatia
Te ngakau ko Tukino
Kia utaina ki te tiwai, e hoe au ki tawhiti
Ki au, i tauhou au ko Whakaari
Ki te puke tapuku Paepae-o-Aotea
Kia takahia atu te moana o Kupe
Ki Whanga-ra ko Matioro
Ka toi au ki Hawaiki, ki te kai ra i rauri (rari) noa mai
Te raweketia e te ringaringa
Me whakatangi te korowhiti ki Tauri-toatoa,

Kia Te Ngahue, ki Matakawa, kia Te Pori-o-te-rangi
Ko te au ra i nohoia e te takupu o te Whai-a-Paoa
Kia ope noa te kutikuti, kia ope noa te whakairoiro
Hai maru haerenga mo maua ko taku tamaiti poriro.
Mo Tu-wairua, mo paki kau noa mai
E te ngutu o te tangata.
Nau mai hoki ra, e te iwi!
Kia kite koe i te whare whanaunga tamariki
Ka whakaaro-rangi tenei ki Tikirau, kia Te Puta-hou
Kia tawaria taku tua ki te kope rawhiti ki tae iho
Me kore te matarae i Whanga-paraoa
Ko te Wewehi-o-te-rangi
E aki kau ana te tai ki Ahuriri
Ka tika tutuki te koronga ki te Kaha-makau-rau
Kia te hoa a Tiki ko te rawa hoki e Whata
I whakairia ai toku teke mai tutakina na mata kia karapipiti
Ako rawa ake ki te ai a te tui ko te ngutu koikoia
Na kete tahora mo kai toku whaea i riro atu na
I waiho ai hai hikihiki taua ki te ihu o Pauanui
Ko te hapu pararaki to Peha taua te kiri wharauna
Ki te whare ka to poriro au na
I moe atu aku kanohi kia Tukorehu
Ki te hunga nana i takitaki taku mate
Ka ea Waipohue
Kati ra te whakakeke na i te patanga
Huatakitini te hapai o taitaia Maui
Kia tihao atu te tihi ki Tongariro
Kia matotoru, e rua aku ringa
Ki te haramai ki te aitanga a Tuwharetoa
Hai kai—e.

A Rangi Poi.

Poi maru nui, maru roa, whiu noa, ta noa,
Ki te hika tamariki, ki te hika ropa
Te tauwheke kui, te tauwheke koro ki te hika
Ka haruharuatia, ka ewe kuritia
Ka hanga ta te pakeke pirori haere ai
Te mahi a te pakeke ka motu kai te wha
Kai te whakapohanehane tara kai raro
Matoetoe ano te waruhanga e tu nei
Te whakatau iho, te whakatau ake
Kai hea he ara rerenga mai e te poi
Kei Kawhia, kei Marokopa, kei te akau
Kei te tipuranga mai o te poi—e ha!
I kinitia i te tou o te tamariki
Whainga whekiki ki au—e poi e.

A Rangi Poi.

Tenei te poi, tenei te poi
Horohoronga e to ringaringa
Hokohokona ki te tamaiti
Tamaiti rurenga rau, e ha!
Hurua ki raro ki te kăkă
Ka kotamu toku, ka kotamu to Ngaroria
Ka kotamu ki taua tangata
Tahi ano ko te pakuru anake
E hia po e whai atu ai, ka tahuri mai tu Hakaraia
Haere, whakataha te haere
A kura-winiwini tara koa

Kai hea he ara rerenga mai mou, e te poi
Kai Kawhia, kai Marokopa, kai te akau
Kai te tipuranga mai o te poi—e ha!
Kinitia i te tou o te tamariki
Whainga whekiki ki au
E poi—e!

A Rangi Poi.

Poi marungarunga iho, mararoraro ake
Tupotupou ana ka eke kaipuke hamua
Kei whea he ara rerenga mai mou, e te poi," &c. (see *ante*).

A Rangi Poi (composed by Ruinga-rangi).

Poia atu taku poi, wania atu taku poi
Nga pikitanga ki Otairi
Papatairite mai ki Patea
Ka tirotiro ki te One-tapu, taiawhio tonu ki Taupo
Ko Te Rohu, ko Te Rerehau
E whae ma! Kia tika mai te whakaaro ki konei
Mo aku haere ruahine ki kona
He nui tonu mai, he iti taku iti
Ehara i muri nei no tua whakarere
No aku kaumatua i whaia ki Heretaunga
Ko Puoro-rangi, ko Tarapuhi ki rawe ra
Maua taku tara ki te hapai awe
Ki nga whenua tapapa ana i te hiwi ki Horohoro
Ka matau tonu au ki Tarawera, ko Te Hemahema
Ka rere titaha te rere a taku poi
E oma ana i te tai pouri ki Rotorua
Ko Pare-hokotoru, ko Te Apoapo, ko Ngatoro
Kai hea te rae ka hapainga mai,
Kai Tauranga (a) Tupaea
Ko te mea ra e wawatatia e maua ko taku poi
Tiherutia i te wai ki Hauraki, ko Hapai, ko Taraia
Tu tonu mai taua-iti kai Mahurangi
Ko Te Ao-hau, ko Tiaho
Ka taupatupatu te rere a taku poi
Nga ia tuku ki Wai-kato
Ko Potatau, ko Te Paea, ko Matutaera
E taoro nei i te nuku o te whenua
Hai mana mo Aotea-roa, potaea.

Titi-touretua.

Here is another game of the *whare tapere* of old. The *titi-touretua* is played by six or more persons, who sit in a circle a little distance apart from each other. Four sticks, some 2 ft. or 2½ ft. in length, are used. These are sometimes quaintly carved. Four of the players have each a stick, held vertically before him in the right hand. In time to the accompanying song they swing these sticks up and down, and, at a certain word in the song, the sticks are thrown to others across the circle and dexterously caught. The sticks are thrown simultaneously, and must not be allowed to strike each other in their flight. Every movement is performed at the proper time, which is given by the song sung by the

players. One movement is to throw the sticks round the circle of players. At other times, instead of swinging or throwing them, they must be lowered until the lower end rests upon the floor, the song giving the cue for all these different motions. At other times the sticks are thrown across the circle, but always they must be caught by the proper person. It is quite interesting to watch. The players sometimes kneel instead of sitting at this game, and the former is probably the correct attitude.

The following is a *ngari titi-touretua*, or time-giving song or chaunt, sung by the players of the above game :—

Titi torea
Whakanoho ke te kupu o te karakia
Ko ana titapu hoki te kapu
Ko te ra to hoki ka riakina ki runga
Ka hakahaka ki raro, aue
Ara ra mai tahi, mai rua, mai toru
Mai wha, mai rima, mai ono
Mai whitu, mai waru, mai iwa
Mai ma ngahuru
E ka whakakopa ona perehina
Ki te huruhuru tipua—e
Koi heri, koi hera, maka titi, maka tata
He maka titi he mea
A ka turia te tara o Moetara
Te tara titi touretua.

Matimati.

This game is played with the hands alone. Either two or more persons play at it, the players sitting opposite to each other, and playing the game in pairs. A long series of words or short abrupt sentences is repeated by the players very quickly, and this alone is quite difficult in order to avoid making an error. At each signal-word or remark the hands are quickly moved, each time in a different manner. We give an example of this game below :—

First cry: "*Matimati.*" (The players here strike the closed hands together.)

Second cry: "*Tahi matimati.*" (The same action.)

Third cry: "*Rua matimati.*" (The hands opened, fingers apart, right thumb struck across left.)

Fourth cry: "*Toru matimati.*" (The right hand clenched and struck on open palm of left hand.)

Fifth cry: "*Wha matimati.*" (The two hands open, brought together and fingers interlocked.)

Sixth cry: "*Rima matimati.*" (Thumb of right hand struck between first and second fingers of left hand.)

Seventh cry: "*Ono matimati.*" (Same as first movement.)

Eighth cry: "*Whitu matimati.*" (Same as No. 3.)

Ninth cry: "*Waru matimati.*" (Heel of hands struck together.)

Tenth cry: "*Iwa matimati.*" (Same as No. 1.)

Eleventh cry: "*Piro matimati.*" (The open right hand struck on back and front of open left hand.)

The word "*piro*," as used in games, means much the same as our word "out" as applied to game-players—*Cf.* "*piroku*," v.i., go out; be extinguished.

The game of *ti ringaringa* is similar to the above, and is most amusing to watch.

Pakuru, or Pakakau.

This is merely a piece of wood, one end of which is placed between the teeth of the operator; the other is held in the left hand, while in the right is held a smaller stick, which is struck upon the other, and thus time is kept to the special songs sung. The *pakuru* is made of matai, mapara, or kaiwhiria wood. It is about 15 in. in length, about 1½ in. wide at one end, and ¾ in. at the other. It is flat on one side and convex on the other. These were sometimes carved and sometimes plain, or with serrated edges. In former times many persons used to take part in this amusement. We give below two specimens of the *rangi pakuru*, or songs sung:—

Kiri pakapaka, kiri pakapaka
Kiko kore, kiko kore, kiki
Tau ka riri, ka riri
Tau ka rara, ka rara
Kai patuki, patu kahakaha
Hai kona turei ai tana niho, tana niho
Pakakau, pakakau, tu tahi, tu rua, tu toru,
Tu wha mai na ki to mate o te aitu
Tōtō poro kuri, poro kuri, poro tangata
Poro tokorua nga whakahaukanga
Kiki poro, ki poro, ki poro, ki poro kuri
Toro rororo, turi raukaha, kiki to.

A Rangi Pakuru.

Hara mai ana te riri i raro
I a Muri-whenua, i a Te Mahaia ra
Ehara ra teke pakupaku e ko
Kai te uru, kai te tonga
Kai te rakau pakeke—khi—aue!
Takoru te raho o Te Kete
I te ngaunga iho a ta Taiarorangi—ha!
Kai riri koe ki te waihotanga iho
O te parekura
Ko Maunga-tautari
Te tangata tirotiro mo te aha ra
Mo te hanga ra
E tatari tonu mai te hanga kiki to
Toro rororo, turi raukaha, kiki to.

Karetao.

The *karetao*, or *keretao*, known among Nga-puhi Tribe as "*toko-raurape*," is a wooden figure in human form, often ornamented with carving, and the face thereof tattooed in the orthodox lines, the lines being blackened by the use of soot of

the mapara wood, as in the tattooing of the human body. This figure is usually about 18 in. in length; a portion of the timber projects below the legs, in order to serve as a hand-hold. The arms are loose, being merely semi-attached to the figure by means of strings which pass through holes in the shoulders of the figure and are secured to the upper parts of the loose arms. The two strings are fastened together behind the figure. The operator held the figure in one hand by grasping the hand-hold base or projection. In the other he held the cord, which, being pulled taut, caused the arms of the figure to be gripped firmly to the shoulders, and were thus made to assume different positions, both in front or both extended backwards, or one extended in front and one behind. At the same time the arms were made to quiver as in a real *haka à la* Maori, the movement being imparted thereto by the hand of the operator. A specimen may be seen in the Auckland Museum. We give two *oriori karetao*, songs chaunted while putting the figure through its paces:—

Kohine, kohine
Tutara koikoi tara ra
Wheterotero koi arai ake
To marutuna, to maru wehi.

The following is an *oriori karetao* composed by Hokina for a *karetao* known as "Tukemata-o-rangi":—

E rua aku mate, he kauwhau pakihore
Whakatau rawa atu te aro mai ki ahau
Pau te whakatau, he tangata rakau mai
Me whakahinga te whare a Pohe, a Uhia
Koinei kahu tai moana
Whakaeke i waho ra, he kahuhu waiarangi
Tapoto ki to ringa, me ko tahuna—e
Hei rakau a tungatunga turanga riri
A te koroua i te ao o te tonga
Hoki mai ki muri ra
Kia hoaia atu te maro o Tawhaki
. . . . i runga o Te Inaki
Tapuitia mai na taumata—e
. . . . ka pae roto Te Papuni
Ki te iwi ka ngaro
Na to tupuna ra, nana i oro i te whenua
E tama—e! Tenei ou tupuna kai te morehu noa
A mana e ui mai—e ahu ana ki hea?
Horo te ki atu—he mate ka tuatini no to papa
E moe tonu mai rara roto Waihau
Ma wai e whakaara te mea ka oti atu
E tama—e!

TOKERE, OR BONES.

These were made of matai or mapara wood, and were used in the same manner as with us, a pair in each hand. The same songs were used for the *tokere* as for the *pakuru*.

Riddles; Guessing Games; Kai, or Panga.

These are simple. A person will take some small object and show it to his companions. He then brings his two hands together and draws both across his mouth. One is then allowed to guess where the object is. It may be in either hand or in the mouth. When one guesses aright he then becomes leader. Or the small object may be between two of his finger-tips, all being pressed together.

Kororohu, or Pururohu, or Porotiti.

This is a small, flat, and thin piece of wood, matai or mapara, about 3 in. long. Some are rounded at the ends, and some left square or brought to a point like a tipcat. Two holes are made near each other in the centre, and an endless string passes through same. By pulling the string in opposite directions the stick is twirled rapidly round in alternate directions, making at the same time a whizzing noise. The bights of the cord are placed over the thumbs of the operator. The following was sung while operating the *kororohū*:—

A Ngari Porotiti (Kororohū).

Ka kukume, ka kukume au
I te tau o taku porotiti
Ki whakaawe ki Rangi-taiki
Ko Te Koha, ko Muru-takaka, ko Te Ahi-kai-ata
Ko te Koroki, ko Poututu, ko Te Au-tahae
Ka hoki mai te tau o taku porotiti
Hu-hu, wheo-wheo!

Purerehua, or Bull-roarer.

A thin, flat piece of matai wood, an elongated oval, 18 in. or more in length. A cord about 4 ft. long is attached to one end, the other end of the cord being fastened to a stick 3 ft. in length, which serves as a handle by which the operator swings the "roarer" round, causing it to make a loud whirring, booming sound. This noise is said to be made by the *wairua* (spirit) of the operator. A similar belief obtains among certain Australian tribes, who use these bull-roarers at certain rites and initiation ceremonies.

Porotiti.

This has also been described to me as the name of a teetotum made from a piece of gourd-rind pared down and having a small sliver of wood stuck in the centre. It was twirled by this stem between the thumb and forefinger.

Whai, or Cat's Cradle.

The principal string game of the *whare tapere* of yore was the above, known in full as the "*whai wawewawe a Maui.*" It was a favourite amusement of young people, and the elders

often took part in it. A great many different patterns obtained, some of them being most intricate and difficult to acquire. One pattern is known as "*te waka-o-Tama-rereti*," and when made the following lines were repeated:—

Hoea te waka o Tama-rereti
Ki te take harakeke
Hoea!

Another pattern was termed the "*Tiremiremi*," and when formed the parts were worked to and fro (*me he tangata e ai ana*) to the following words:—

E ai ana hoki, e pare he ana
Te waha o to kotore ki rau o te whenua
Ira to puta, te kainga o te ariki
Aua nene, aua rekareka.

Te whare-o-Takoreke, another design, is supposed to represent a house decorated with carvings, while *te whare-totokau* represents a plain house. Takoreke, above mentioned, was an ancestor of very remote times. He was the husband of Hine-te-iwaiwa, of immortal fame, she who invented the art of weaving, and who is looked upon as the mother and patroness of the ancient *whare pora*, or school of weaving.

Other designs in *whai* are: *Te ahi i tunua ai te manawa o Nuku-tau-paroro, te ana o Karanga-hape* or *te ana i Taupo, te whakahua horopito, pae kohu, te tutira o Maui, te rara matai* (represents a tree with branches), *tu-nui-a-te-ika, te whare pora, komore, tama-a-roa, tamāhine, mouti, wiwirau, wharepuni, tonga-nui.*

This game of *whai* is said to have been invented by Maui-pae, as well as the string game termed "*pa-tokotoko*." The originator of tops is said to have been Maui-mua, while the *tekateka* is ascribed to Maui-tikitiki. Hence it would appear that the Maui family are well represented in the *whare tapere*.

PA TOKOTOKO.

This is another string game. It is played by two persons. Each is provided with a piece of string with a loop at one end—a running noose. It is held between the thumb and forefinger of the right hand. The players make passes at each other's hands, each endeavouring to snare or catch the extended forefinger of his adversary in the loop of the string. Each player has seated beside him, or her, a female companion, termed the "*ruahine*." When a player succeeds in snaring the finger of his opponent he quickly touches the hand of the latter with his own, and then turns and touches the hand of his own *ruahine*. This act transfers the *ha* (strength or dexterity) of his opponent to his *ruahine*, who really holds the skill or cleverness which he may display in

the game. In regard to the term and office of the *ruahine*, this is an aping of more serious matters. In olden times a woman was usually employed, under priestly direction, in taking the *tapu* off a person or house, &c. This woman was termed a "*ruahine*."

The taking or abstraction of the dexterity of one's opponent, as above described, is on the same lines of belief as the taking of the *hau*, or vital life principle of the human body, and thus causing the death of the individual. The *ruahine* could cure a person suffering from the evil effects of transgression of the laws of *tapu*, and was an extremely useful sort of person to have in camp.

Musical Instruments.

Several forms of nose and mouth flutes were manufactured in olden times from wood and bone. The former were termed "*koauau*" and the latter "*pu-torino*." Young men or chiefs would amuse themselves of a summer evening by playing on these instruments as the people were assembled in the *marae*, or plaza, of the village. Chiefs at such a time would probably be seated on the *tapurangi*, a stage or platform erected in front of the house occupied by a chief. Songs were sung to the sound of these flutes. One such, a *rangi pu-torino*, is given in "Nga Moteatea," at page 175.

Other instruments used were the bones and *pakuru*, already described. The *pu-tatara* are a sort of trumpet made from a sea-shell. They were sometimes carried by chiefs in olden times, who would use them to summon his people or to announce his approach to a village. The *pu-kaea* was a long wooden trumpet, about 6 ft. in length; it was used in war to assemble the fighting-men, or to give warning of an enemy's approach. A sort of imitation *pu-kaea* was made by children from leaves of the native flax wound in a spiral manner.

The *pahu*, or war-gong, was made by hollowing out a piece of matai wood. The ends, by which it was slung between two uprights on the watch-platform of a fort, were sometimes ornamented with carving. It was struck with a wooden mallet.

Korero Tara.

A favourite amusement during long winter evenings was the repeating of fables, folk-lore, and weird legends, the whole being included under the term of "*korero tara*," or "*paki-waitara*." Some of these would be fables of olden times, handed down for centuries by succeeding generations. Such are the fables of the ant and the cicada, that of the lizard and the gurnard, and that concerning the Wai-kato and Rangitaiki Rivers in their race for the sea; as also the wild legend

anent the forming of the Whakatane and Wai-mana Valleys, and that describing the weird journey of Maunga-pohatu, Putauaki, and Kakara-mea Mountains from the south. We give a specimen of these fables :—

The Popokorua and the Kihikihi (the Ant and the Cicada).

The ant said to the locust, "Let us be diligent and collect much food during the summer-time, that we may retain life when the cold season comes." "Not so," said the locust; "rather let us ascend the trees and bask in the sun, on the warm bark thereof." So the ant remained on the ground and worked exceeding hard, collecting and storing food for the winter. But the locust said, "This is a fine thing, to bask in the warm sun and enjoy life. How foolish is the ant that toils below." But when winter arrived and the warmth went out of the sun, then the locust perished of cold and hunger. But the ant, how snug is he in his warm home underground, supplied with an abundance of food.

The Song of the Locust.

He pai aha koia taku pai
He noho noa, piri ake ki te peka o te rakau—e
E inaina noa ake ki te ra e whiti nei
Me te whakatangi kau i aku paihau—e
Hohoro mai, e te hoa,
Kauaka e whakaroa ara ra
Ka turua ta te popokorua
Rawe noa ta nga taki whakahau
Hau mai ki te keri i te rua
Mo te ua o te rangi me te makariri
Wero iho i te po nei—e
Me te kohi mai ano i te kakano—e
Hai o mo tamaroto
Kia ora ai—e.

Often stories were improvised at these nightly meetings—simple, old-world tales of a primitive people, tales modelled on ancient prototypes of the past, tales of strange beings in human form who dwelt in lone forest depths and occasionally carried off women from the villages of man, and tales of daring voyagers of old who went down to unknown seas in their frail craft, and saw strange sights and strange people in far-off lands. I have often listened to such stories in the murky sleeping-houses of Tuhoeland.

Children's Games.

Upoko Titi.

This game is played by three or more children. Each player crooks the little finger over the next, that again over the next, and that over the forefinger. Both hands are

served alike. One player then holds his right hand out with the forefinger pointing downwards. Another player places his right hand in a similar position, the end of the forefinger resting lightly on the back of the other player's hand, and so on, each player so placing his right hand. The first then places his left hand in like manner on the top hand, and so on until each player has both hands in the pile. The child whose hand is uppermost then repeats:—

Te upoko titi, te upoko tata
Ki te wai nui, ki te wai roa.
Whakatangihia te pupu
Haere ki to kainga!

As the reciter repeats the last word he lifts the topmost hand and thrusts it away. The owner of the said hand then holds it with the forefinger against his, or her, breast, and so on until all the players are standing with their hands pointing so to their breasts, the forefinger just touching same. The leader then asks, "*Ma wai taku ihu e kai*" (Who will eat my nose)? Another will reply, "*Ma te atua*" (The demon will). The leader repeats, "*Waewae nunui, waewae roroa, pokia ki te ahi!*" At the last word all the players cast down their hands with a motion as if throwing something down. The leader then asks, "*Ma wai taku kanohi e kai?*" and receives the same reply, all hands being again thrust downwards. And so on, naming each time some portion of the body, the final question being, "*Ma wai taku tinana katoa e kai*" (Who will eat my whole body)?

Tara-koekoea.

In this game each child closes the thumb and three fingers on the palm of the hand, leaving the forefinger projecting. All hands are then piled on each other as in the *upoko titi*, except that the forefinger points upwards. Then all the players repeat the following:—

Ka haere, ka haere a Para
Ki te wero kuku, ki te wero kaka
Ka tangi te tara koekoea.

At the last word of the jingle the players all snatch their hands away and place them behind their backs, but as they do so they endeavour to strike or touch the hand of another player. Any player so touched is out of the game.

Hapi Tawa.

Two or more play at this. Child No. 1 places his, or her, open hands together, with the palms pressed against each other and held out in front of the body. Child No. 2 draws

his hands over those of No. 1—*i.e.*, stroking the back of them towards himself, and repeating this:—

Hukea, hukea,
Te hapi papaku
Ma to kuia
Ma Whare-rau-roa.
Kia hoki mai
I te kohi tawa
Kinikini raupaka
Te hoia to taringa
He hapi kumara
He hapi taro
He hapi kereru
He hapi Koko
He hapi kaka.

Child No. 1 asks, "*Na wai koe i tono mai?*"
Child No. 2 replies, "*Na Pitau.*"
Child No. 1 asks, "*Pitau whea?*"
Child No. 2 replies, "*Pitau toro.*"
Child No. 1 asks, "*Toro hea?*"
Child No. 2 replies, "*Toro tai.*"
Child No. 1 asks, "*Tai whea?*"
Child No. 2 replies, "*Tai matua.*"
Child No. 1 asks, "*Matua wera?*"
Child No. 2 replies, "*I te ahi.*"
Child No. 1 asks, "*Pi koko?*"
Child No. 2 asks, "*Me aha koia?*"
Child No. 1 replies either "*Me whakaora*" or "*Me patu.*"

Should the first of these replies, meaning "Spare him," be given by No. 1, he will receive a light box on the ear. Should the second answer, meaning "Strike him," be given, he will then be spared the blow.

Child No. 2 then takes the hands of No. 1, which are still pressed together, and bends the two thumbs away from the fingers, saying, "*He hapi kumara.*" He then pushes the two forefingers over against the thumbs, saying, "*He hapi taro.*" And so on until all the pairs of fingers are pushed over and are thus close together again. No. 1 then opens his hands in cup form, into which No. 2 darts an extended thumb and forefinger, as if hastily picking something out of the hollowed hands. Meanwhile No. 1 tries to catch the hand of No. 2 as it is thus darted. When so caught the game is ended.

Kura-winiwini.

In this game a string is used, one end of which is held in the mouth of one of the players, who are seated in double lines facing each other. The string passes down between the two lines, and each player on either side grasps it with both hands, thus the string is hidden from sight. The game lies in guessing where the free end of the string is, and in carefully

concealing the same. Sometimes the player who holds the end in his mouth will draw in the string until he has it all concealed in his mouth, but the hands of the others are kept in position as though still grasping it. This is baffling to the guesser. The following *ngeri*, or chaunt, is recited during the game :—

Kura, kura
Kura winiwini, kura wanawana
Te whaia taku kai nei
Ki te kai patiti, ki te kai patata.
Ka rawe taua ki hea?
Ka rawe taua ki pahu nui, ki pahu roa
Hai tako titi, hai tako tata
Haere pakiaka
To reti kai whea.

Tatau Tangata.

The children form in a circle and one repeats the following doggerel. It is repeated in a jerky manner, as shown by the placing of the commas, and at each of the latter the reciter points his forefinger at one of the ring of children, and keeps on thus round the circle. The player at whom he points at the final word falls out, and so on until only one remains, who is said to have won :—

Tokotahi, tokorua, e ka, kurupatu,
Te oia, te kotiti, te kowhewhe, i waiho, i reira,
E whewhe, tikina, toetoea, he karaka,
Hai wero, mo to, iwi, tuarua, taro, pahaba,
Ki runga, i te karaka, toro, pahaha,
Te mea ao, to whaea, koro houa.

Tatai Whetu, or Tatau Manawa.

The following doggerel was repeated by children, the object being to see who could go through it in one breath. But it was also used as a *tatai whetu.* The latter was a singular act performed in former times in order to kill a frost —*i.e.*, to stop a frost and cause the night to become warm, thus saving the crops. A person would take a firebrand and proceed to the urinal of the settlement, where he would walk round, waving the firebrand so as to light up the ground. Then, throwing the firestick away, he would face to the east and repeat the following two effusions, holding his right arm up, and with index-finger point from one star to another as he kept repeating his jerky lines, as a person does when counting a number of objects :—

Katahi, ka ri, ka wara, ka tikoki,
Manu ki, manu ka toro, kai o, tungongo,
Kai te, koata, raua riki, tara kaina, e hi,
Tarera, e tika, ra waho, tikina,
Kapohia, te arero, o te rangi,
Wiwi, wawa, heke, heke,
Te manu ki, ki taikeha.

A Tatai Whetu.

Katahi ti, ka rua ti, ka hara mai, te pati tore,
Ka rauna, ka rauna, ka noho, te kiwikiwi
He po, he wai takitaki, no pi, no pa,
Ka huia, mai, kai ana, te whetu,
Kai ana, te marama,
Ko te tio, e rere, ra runga, ra te pekapeka, kotore,
Wiwi, wawa, heke, heke,
Te manu, ki o, tau, tihe.

OUTDOOR GAMES.

Not but what the foregoing games, &c., were not played out-of-doors, but what we propose to deal with now are the special outdoor games, &c.

Wi.

This is similar to one of our own boys' games. A circle, known as the "*wi*," is formed on the ground, and the players stand round it. The base or *wi* keeper then recites the following *tatau tangata* in the jerky manner and with the same actions as described above:—

Pika, pika, pere rika,
Papa rangi,
He, hi, rate, mai,
Hau, haunga, te, hati, mai, putu,
Piki, piki.

On repeating the last word of the above the child at whom the reciter's finger then points drops out, and so on until but one is left, who then becomes base-keeper. The children then endeavour to enter the *wi*, or base, without being touched by the base-keeper, whose business it is to defend it. Should any be touched before entering the *wi* they must then assist the base-keeper in defending it. Those who succeed in entering the circle without being touched are said to have won. A base-keeper will sometimes pursue players in order to tag them. The term "*piro*" is applied to those who enter the base untouched (*kua piro a mea*).

Tops.

The ancient Maori tops were of two kinds—the *potaka ta*, or whip-top, and the *potaka takiri*, or humming-top. As already stated, the top is said to have been invented by Maui.

The whip-top was similar to that used by us in the days of our youth, and was whipped in the same manner, the whip being made from the fibre of the native flax. These tops had sometimes small pieces of sea-shell* inserted, countersunk in the wood, which shells would, of course, form apparent circles

* Either a white shell or the shell of the *pāuă* (*Haliotis*, mother of pearl, the *abalone* of the Californian coast) was used. The whip was termed a "*kare*."

as the top whirled round. Small hurdles were sometimes erected, over which the tops were whipped. The *potaka whero rua* was a double-ended whip-top, pointed at both ends, and was made to turn ends by means of the whip. Tops were made of matai, mapara, or totara wood. "*Kai-hōtàka*" is given in Williams's dictionary as meaning "a whipping-top," but that term is not used among Tuhoe.

Some of the humming-tops were made of wood, and were solid like the whip-top.* Both were of the same form, save that the whip-top was flat on the top, while the humming-top had a piece of wood projecting from the top vertically, in order to receive the string. This upright piece would be part of the original piece of timber from which the top was made, and was not an inserted piece. The body of the humming-top was also larger and longer than that of the whip-top, and was a solid piece of wood.

The word "*potaka*" means a top. "*Ta*" is to beat, hence the name applied to a whip-top. "*Takiri*" means "to loosen; to draw away suddenly; to start or fly back, as a spring," &c. As applied to the humming-top, the word refers to the mode in which the top is set up by the operator.

The string used for the humming-top was a thin, strong cord made from fibre of the native flax, the kind of cord known as "*karure*," which is made by twisting together two miro, or twisted threads of fibre. This string is wound round the piece of wood projecting from the head of the top. The handle or hand-hold by which a purchase is gained is a small, flat piece of wood, and is known as the "*papa takiri*." It is not slipped over the upright projection of the top as with us, but is held against the side thereof. This *papa* is about 6 in. in length and ½ in. in width.

In former times children liked to see their tops "asleep" when spun. To describe this state the term "*newha*," or "*anewhanewha*," or "*tunewha*" is used. In the following effusion, which is a *kai-oraora*, composed by one Te Horo in revenge for the death of his son Pohokorua, these terms are evidently used as meaning "dazed by grief."

A Tangi Kai-oraora.

Pinohia ki te kowhatu
Ka korowhiwhitia ake tona roro
Ote tohunga nana nei au
Koi huna ki te po
Ui mai koia—he aha te rawa?
He manawa whiti, he manawa rere,
He manawa kapakapa
Ka noho kai a te ihu.

---

* Not that the solid tops hummed much, but I have no other name for them. They were spun as we spin humming-tops. The gourd tops made a loud humming noise.

Whiti Tuarua.

E kui ma! Kia ata tono mai ki ahau
Kaore raia he iwi tu atu ki runga ra
E taia ana au e te mate
Kai te potaka tu-newhanewha,
Ka taia, ka haere, ka anewhanewha.

Humming-tops were also made of a small *hue*, or gourd, through which a stick was thrust and both ends thereof left projecting, the lower one to serve as a spinning-point and the upper one to wind the string on. A hole was made at one side of the gourd, which caused a humming, wailing sound when the top was spinning. This was the true humming-top; the name was used by myself to denote the wooden *potaka takiri* for want of a better term.

These gourd humming-tops entered into a very singular custom among the denizens of Tuhoeland and adjacent peoples. They were used in order to avenge death, in the same manner that the wailing of a lament or dirge, with weeping, was said to avenge the stroke of death. This is a world-old idea, a relic of universal personification of all natural events, &c. As the men of old said, "*Ko roimata, ko hupe, anake nga kai utu i nga patu a aitua*". (By tears and grief only may the strokes of misfortune be avenged).

Humming-tops were spun that the wailing sound thereof might accompany the lament for the dead chaunted by the people after a defeat in battle. The humming of the tops, of which many were used, resembled and represented the murmuring wail of the mourning widows. Appropriate songs or chaunts, termed "*whakaoriori potaka,*" were composed for such occasions, and were chaunted as the tops were spinning.

When after they had been defeated in battle a party of people came to condole with them, they all assembled in the plaza of the village to receive them, and there was chaunted the lament for the dead. And as the lament was sung the wailing tops were spun—*hai ranaki i te mate*—as an avenging of the defeat. The tops were spun at a given word at the conclusion of each *whiti*, or verse, of the song. After this performance was over the tops, together with presents of clothing, &c., would be handed over to the visitors.

Many of the people would be provided with tops for this performance. This custom was revived after the defeat at Orakau. The following *whakaoriori potaka* was thus sung in many a native village after the defeat of Ngati-porou and Te Whakatohea on the field of Maketu:—

Kumea! Toi te roroa o te tangata—e
Ina noa te poto ki te oma i Hunuhunu—e
Hai! Tukua!

Na (nga) morehu, ma te kai e patu—e
Ko te paku kai ra mau, E Te Arawa—E!
Hai! Tukua!

E ki atu ana Karanama, e noho ki tamaiti nei—e
Takiri ana mai te upoko o te toa—e
Hai! Tukua!

Koro Mokena, huri mai ki te Kuini—e
Koi rawerawe ana ou mea kanu kaka—e
Hai! Tukua!

Na Tamehana ano tona whenua i utu
Ki te maramara taro—e
Waiho te raru ki to wahine—e
Hai! Tukua!

At the word "*Tukua*" all the tops are set spinning. When the tops fall then another verse is commenced, and the tops are wound up again ready for the next signal-word.

Kites.

Kite-flying was a favourite amusement in the days of old, but, like most other old-time amusements of the Maori, has long been abandoned. Kites were termed "*manu*," the same word meaning "bird," and were made to resemble a bird in form, with long outstretched wings. The best kites were made of the bark of the aute shrub, or paper-mulberry. Inferior ones were made of upoko-tangata, a coarse sedge or swamp-grass, or of the leaves of the raupo, a bulrush. These kites were very neatly made, the material being fastened to a light frame. Long tails or streamers, termed "*puhihi*," were suspended from the wings (*paihau*) and tail (*waero*) of the kite. Kites made of raupo do not rise well, but sag from side to side. Sometimes shells were attached to the kites, and when flying, should the cord be held, the oscillation would cause the shells to rattle in a manner presumably pleasant to the Maori ear. Shells of the kakahi, or fresh-water mussel, were used for this purpose, evidently on account of their lightness. Adults used to indulge in kite-flying. The kites of children were generally the inferior ones made of raupo.

"In the days of old our people would weave kites, and the wings and body thereof would be covered with aute, hence the name '*manu aute*.' Horns or points would be fastened to the head of the kite. The cord would be secured by which the kite is let out. When the wind rose the people would go a kite-flying (*whakaangi manu*), and many would gather to look on. An expert person would be selected to cast off the kite that it might rise, and, if a large kite, he would have to be careful lest the thing swoop down and he be struck by the points thereof. When the kite rose it would soar away like a bird, and the cord would be paid out as it ascended. Then the *karakia* would be repeated.

"*A Karakia Whakaangi Manu (a Kite-flying Charm).*

Piki mai, piki mai,
Te mata tihi o te rangi
Te mata taha o te rangi
Ko koe, kai whaunumia e koe
Ki te kawe tuawhitu, ki te kawe tuawaru
Tahi te nuku, tahi te rangi
Ko te kawa i hea?
Ko te kawa i Taumata-ruhiruhi
Te takina mai taku manu nei
Ka piki.

"Then a round object, a disc, would be sent up the cord, along which it would travel. It was to take water to the kite, and show that the kite had reached the heavens. And it would reach the kite, although the latter might be so distant as to be out of sight. Then the cord would be drawn in, and finally the kite be recovered. And on being looked at it would be found quite wet. A peculiar wetness this which clings to the kite. It is not like the water which flows here below; it is like dew, or the misty wet which settles upon the high ranges." A reference to the above messenger sent up the cord of a kite may be noted in Mr. White's Lectures, page 176.

Teka, or Neti.

This was a favourite pastime of olden times, and quite a game of skill. It was Maui-tikitiki who invented the game of *teka.* He expectorated upon his dart and repeated this charm:—

Taku teka, tau e kai ai he tangata
Haere i tua o nga maunga
Me kai koe ki te tangata
Whiwhia, rawea.

Then Maui threw his dart, which flew apace and stuck in the jaw of an old man who was sitting in the entrance of the house known as Tane-kapua. The old man's jaw dropped off. Maui arriving, said, "Old man, your jaw has dropped off." The old man nodded. Maui said, "I will take your jawbone with me." That old man was Muri-ranga-whenua, the grandfather of Maui. That jawbone was the hook by which this land was caught and dragged from the ocean depths. The fish caught with that hook was Papa-tuanuku (Mother Earth) herself. The hook may still be seen at Heretaunga.

But about the *teka.* It is a dart, usually made of a stalk of the fern rarauhe, about 3 ft. in length, the after-end bound round with a piece of flax. This dart is thrown so as to glance off the surface of a small mound of earth, which is cleared of weeds and made smooth. The thrower stands a little way behind the mound and holds the dart (*teka*) by the rear end, between thumb and second finger; the forefinger is on the end of the dart, to propel it. The dart was thrown

underhand, so as to glance off (*pahu*) the smooth top of the mound. Each player casts his dart in turn, and he whose dart is cast the greatest distance wins the round. When a player wins his first round he cries, "*Katahi ki rua.*" On gaining his second round he says, "*Ka rua ki toru.*" At the third, "*Ka toru ki wha,*" and so on; thus each player keeps his own tally. The first to win ten rounds wins the game. The cry of a player for the ninth round won is, "*Ka iwa ki ngahere,*" the expression "*ngahere*" being here used for "*ngahuru*" (ten). The cry at the tenth round won is "*Ka piro.*"

Each player, as he proceeds to cast his *teka*, would repeat the following charm to render his cast effective :—

Patu atu taku pehu ki mua
Me he matakokiri anewa i te rangi
Te rokohina ko te teka na Tuhuruhuru
Kia tika tonu te haere
Mau e piki atu, mau e heke atu
I tua o nga pae maunga
Toroi e taku pehu
Ko te pehu, ko te koke
Marie kia tika.

The Topa, or Koke.

The *topa* is an amusement of children. A broad, sound leaf of the *wharangi* shrub is plucked, and into the stem of the midrib (*tuaka*) thereof is inserted the thick end of a culm of *karetu* grass. The caster, standing on an eminence, holds the top of the leaf between thumb and two fingers, and on casting the leaf forth horizontally it will sail on for some distance, and even ascend, before descending to the ground. The descent of the leaf is very gradual, it being balanced by the grass culm. A child would repeat the following charm to cause the leaf to make a long flight :—

Topaina atu ra taku topa nei
Ki tai nui, ki tai roa
Koki, kokere, whai
Tohia nuku, tohia rangi
To kai, topa rere
Ki o rua whangai.

These leaves are sometimes thus cast across a river of considerable width.

Pirori (Hoops).

The hoop is an old-time Maori toy. They were made of a tough forest creeper known as aka tea, the join being neatly bound with a lashing of flax-fibre. They were 18 in. or 2 ft. in diameter. Players stood opposite each other on either side of the *marae*, or plaza, and each held a short stick in his hand. The hoop was not trundled as with us, but was thrown so as

to roll across to the opposite player, who would strike it with his stick in order to drive it back to No. 1; but he would not follow it up. Should the hoop not run true, but wobble in its passage, that is termed a "*tiko-rohe-tu.*"

At page 58, vol. v., of White's "Ancient History of the Maori" is an account of how a certain old-time gentleman, having slain a much-hated enemy, did thereupon flay the same and proceed to stretch his skin upon a hoop, with which he, together with other chivalrous warriors of that ilk, amused themselves, after the manner of their kind, by trundling the aforesaid hoop and belabouring it unmercifully with cudgels.

Hoops were sometimes thrown so as to rebound from the earth and jump over high hurdles.

Reti.

This was a kind of toboggan, and was used on a steep bank or hillside, on which a slide would be prepared and made slippery by pouring water upon it. The *reti*, or toboggan, was a flat piece of wood about 2½ ft. in length and 4 in. or 5 in. in width, square at the rear end and pointed in front, the nose being also "sniped," so as not to catch in the ground, and thus leave the "riding side" of the *reti* free. Two projections were left on the top side for the rider's feet to press against, one foot being placed behind the other. Such was the toboggan, or *papa reti.* The slide was known as *retireti.* "*Papa reti*" is a term applied to an epidemic of sickness wherefrom many die.

Pou-toti, or Stilts.

Stilt-walking was a pastime of the young people. The stilts were often made with foot-rests 3 ft. from the ground. Mimic battles were waged by stilt-walkers, who tried to overthrow each other, the result being numerous and sometimes severe falls.

Swings.

Another amusement over which Takataka-putea presides is the *moari*, or *morere*, a peculiar swing. The Maori had no swing with a seat such as we use. The *moari* was, if possible, erected over a deep pool in a stream or river, or on the shore of a lake. A tall sapling was set up inclining somewhat over the water. On the top of the pole a loose cap of timber was fitted, to which the ends of long cords or ropes were fastened, the ropes trailing down for the players to swing by. As the players hung on to the ropes and swung round the pole the wooden cap thereon revolved, so that the ropes did not twist round the pole. In the case of those set up over water, the swingers would grasp the ropes with both hands

and gain momentum by running round the pole on the land side, and then swing off the edge of the bank out over the water, where they would release their hold of the rope and drop feet first into the water below, which same is the Maori form of diving (*ruku*). This form of diving is done from a height of 40 ft. or 50 ft. sometimes. At some places a running jump is taken from a steep bank into a river or lake, or a pole is secured in a horizontal position over the water, from which the jump is taken. At others, again, a tree growing on a cliff and leaning out over the water is used in a like manner. Such an one is a rata-tree just above the Pari-kino Settlement, on the Whanga-nui River, and from which the jump is some 30 ft. or 40 ft. Some time back a woman was there killed by falling flat on the water, instead of entering the same feet first in the proper manner. It is surprising to see what heights very small children will jump from.

At settlements where water was not available for jumping into, the *moari* was erected at any suitable place near by, where it was used as a sort of revolving swing. One such formerly stood at the Ngati-tawhaki village of Kiritahi, at Rua-tahuna, and was known as Tama-tē-ngaro. Another stood near Māna-tē-pa, a fortified village on the Mana-o-rongo Creek, near Tatahoata. The latter one was named Tara-kai-korukoru. Each of these swings had eight cords. A singular story is attached to these two swings. When my informant had told me of them, he added, "They were erected in order to avenge those of Ngati-tawhaki who were slain at Mānă-tē-pa." This caused me to make inquiries, believing that I was about to lift the trail of some quaint, barbarous custom. I had heard of the inter-*hapu* unpleasantness at that fort, where Te Ure-wera clan had slain three of Ngati-tawhaki, but the swings were new.

"Ngati-tawhaki had fallen before the volley of Te Urewera. Then our assailants migrated to Rua-toki, lest evil befall them. Our people were much troubled over the matter. Then the thought grew: We would avenge that disaster. Tu-kai-rangi, of Tawhaki, rose and caused to be erected those two *moari*. Tama-tē-ngaro was erected just by the cherry grove yonder, and Tara-kai-korukoru was set up by yon kahika-trees on the terrace. Then a song was composed, to be sung by the performers when swinging. And this should be our revenge for the death of our men at Māna-tē-pa. No! Of course, it was not an actual revenge or equivalent for our loss, but it was to dispel the grief and fretting over the death of our friends; hence it was termed an avenging of their deaths—'*Hai whakangaro i te rawakiwaki mo nga mea i mate, koia i kiia ai he takitaki mate.*' Here is the song. The eight ropes of the *moari* would be

manned, and all the performers and onlookers would sing the first verse (*whiti*). At the last word thereof they would swing off and fly round the pole. When they stopped the second verse would be sung, and the performers swing off again."

Whiti 1.

Tu-kai-rangi—e
Hangaa he moari
Kia rere au i te taura whakawaho*
Kai te pehi hiri whakamau
Na wai takahia.

Whiti 2.

Taku aroha kia Te Haraki—e
Nga whaiaipo a te hiri whakamau
Na wai takahia.

Whiti 3.

He taura ti—e. He taura harakeke
Nga taura o te hiri whakamau
Na wai takahia.

A famous *moari* used to stand at Kirikiri, on the shore of Waikare-moana.

Pendent aka, or forest creepers, were often used as swings, and from the swing of them the players would gain impetus for a flying trip through the air to Mother Earth. These were termed "*tarere*," or "*himorimori*." A cross-piece of wood was sometimes lashed on to the aka to serve as a seat.

The *kai-rerere*, or long jump, was another form of amusement. Te Kai-rerenga-a-te-Rangi-houhiri is the name of a crossing-place of the Whakatane River where, in former times, travellers used to cross by jumping from one stone to another, a feat at which Mr. Rangi-houhiri excelled all others, hence the name.

Piu (Skipping).

A long cord was used, a child being stationed at either end to swing same. Several players would skip at the same time. As the game commenced the cord-swingers would chaunt: "*E piu—e! Ka taha te ra ki te rua.*"

Pioi.

The term "*pioi*" was applied to the seesaw, a pole balanced across a log, as our own children play; and also the name was applied to a limber branch, usually of a fallen tree, and which players would bestride and cause to swing up and down.

Concerning the *pioi*, let me tell you an anecdote. In the days when Ngati-mahanga, of Te Whaiti, they who slew the Drooping Plume and erstwhile went down to Hades before

* The outer cord is the most difficult to manipulate.

the stabbing spears of Tuhoe—when the Children of Mahanga, I say, were sore beset by the Hine-uru clan of Tarawera they bethought them of applying to their overlord for armed assistance. A band of Tuhoean mountaineers therefore marched to the Wairoa Fort, on the Upper Whirinaki. On their arrival, however, instead of having food presented to them, as is usual in such cases, a great nothingness prevailed, and no refreshments were forthcoming. Then the heart of the Child of Tamatea became sad within him, for Tuhoe, albeit famous warriors—as we ourselves discovered in later times at Orakau and elsewhere—are a most touchy people, and passing rich in dignity and sense of affront. They therefore, with intent and malice aforethought, and doubtless being possessed of the divine afflatus, did proceed to compose a most virulent *ngeri*, or jeering-song, as a scathing rebuke to their churlish hosts. Hard by the fort of Te Wairoa was a famous *pioi*, a swinging tree-branch of great length and elasticity. On this branch the Children of the Mist ranged themselves, and, swinging high to the spring of the weighted branch, roared forth their incisive song of derision. After which, their anger and hunger being still unappeased, and possibly annoyed at the "innocuous desuetude" of the Sons of Mahanga, they fell upon them, smiting them hip and thigh, with the result that several of them were soon killed, cooked, and eaten.

The above is not necessarily a form of amusement or pertaining to the *whare tapere*, nor do I know that Takatakaputea and Co. would countenance such acts. It is merely inserted here as a quiet hint to any luckless wights who may find themselves neglected by their hosts.

Foot-races.

Foot-races over long distances were sometimes arranged. A certain place would be agreed upon, where, as soon as one of the runners arrived, he would leave or make some mark, on a tree or elsewhere; and this mark would be pointed out with pride by his descendants. A foot-race of this kind took place from Te Whaiti to Te Teko, a distance of nearly fifty miles.

Sling (Kotaha).

I am informed that slings made of flax-fibre, used for slinging stones in play, were formerly used, and were termed *kotaha*. I am not clear that they were used prior to the advent of Europeans. The term "*kotaha*" was also applied to the whip used in casting the spear known as a "*tarerarera*," which was so cast into besieged places.

The *kakere* was an amusement of children, sticking some

object on a stick and "flirting" it off, tc see how far it could thus be cast.

Ripi (Ducks and Drake).

Same as with us, the skimming of flat stones along the surface of water. The name is also applied to the throwing of flat, rounded pieces of bark upwards. This would be done near a tree, to enable the children to see which player flung the highest.

Bow and Arrow.

The Maori of New Zealand are true Polynesians in their non-use of the bow and arrow. It was never used by the Maori in war. Some natives here assert that the bow and arrow were used as toys in olden days, but I have met with nothing in tradition or song to support the assertion. The word given me for "arrow" is "*kopere*," a term applied to the sling or whip by which spears are thrown.* The term given me for "bow" is "*whana*," which would be applied to anything curved or bow-shaped. I am told that a bow of supplejack was used by children, with an arrow made of a fernstalk, the rear end of which was bound with string, and the head was furnished with a point of katote, the hard black fibres of the kaponga, or fern-tree. It is said to have been used for killing birds. Personally I have no faith in the bow and arrow being used in pre-*pakeha* days.

In the first place, the games and toys, implements, weapons, &c., that were used in ancient times are mentioned in many historical traditions, legends, stories, songs, &c. In none of these have I ever noted any allusion to the bow and arrow. Certainly the term "*pere*," meaning "a dart," is met with, but it refers to the spear thrown with a whip. Other tribes may have had some knowledge of the implement in former times, but I do not believe that Tuhoe had. In the second place, many European words, implements, foods, and arts reached the remote inland tribes long before such peoples were brought into contact with white men. Hence they often assert that some art, or vegetable, or English expression was known before the arrival of Europeans, whereas it was not, but filtered through other tribes before Europeans were known in the interior.

Taupunipuni was a game like our "hide and seek," played by children.

Poro-teteke was a boy's amusement of walking on the hands with feet in the air.

It is most amusing to note small children playing—the peculiar things they do and say. You may see two mites

* Probably also to the spear so thrown.

sitting gravely opposite each other, each one trying to make the other laugh. One will take the other by the hand and then draw its other hand down the arm, repeating, "*Paki-paki te whatitiri, No—e ! No—e !*" until one of them is fain to laugh.

I have heard children repeating the genealogies of the village dogs in true orthodox style, learned while listening to the recital of tribal genealogies in the sleeping-houses.

Small girls will play at imitating the labours of their mothers, and will make little steam-ovens and collect and earth over potatoes in true *koputu* style, or carry appalling swags of firewood weighing several pounds.

Para-whakawai.

The *para-whakawai* may be termed a "school of arms." It is applied to meetings of young men on the plaza of the village for the purpose of acquiring and practising the use of weapons, such practising being known as "*whakahorohoro rakau.*" Such practice, or trial of arms, is carried on under the eyes of veteran warriors, who are known as "*Ika-a-whiro.*" Here the young Maori learned to use the arms of old—to guard, parry, thrust, and strike. Wrestling was also indulged in, and women used sometimes to join in this—probably two women opposed to one man. Some of the women were famous wrestlers.

Whatoto (Wrestling).

This was a common amusement among young men, and much interest was displayed when two noted wrestlers were pitted against each other. My notes under this head are, however, meagre in the extreme. The various holds or grips were termed "*awhiawhi,*" "*uru-tomo,*" "*tăhă,*" "*whiri,*" and "*whiu.*" The *rou* was the thrusting of the leg between those of the opponent in order to throw him.

When a man was about to engage in a wrestling bout he would expectorate into his hand, which he would then close and repeat the following charm (*karakia*) to strengthen him:—

> Taku uaua ko te rangi e tu nei
> Taku uaua ko papa e takoto nei
> Whiri kaha, toro kaha te uaua.

Then, opening his hand, he repeats a second charm to weaken his enemy and render him powerless:—

> Te umu a te ruhi, a te ngenge
> A te paro (?) a tineia kia mate
> Te umu tuku tonu te ika ki te Po
> Te umu tuku tonu, heke tonu te ika ki te Reinga
> Ka mui te rango, totoro te iro
> Kaki whatiia.

This latter charm or spell is known as "*tuaumu*," and belongs to the art of *makutu*, or witchcraft.

The Game of Ruru.

In this game five stones are used. They are round (*potakataka*) and symmetrical; often they were chipped into the desired form by means of striking them with a piece of quartz, as flakes are struck off a flint core. Old men often amused themselves by making them, as well as other toys, &c., as playthings for children, and even for elders, inasmuch as the elderly people often entered into this and other games. Of these stones one was marked and styled the "*hai*"; it was the principal one used for throwing, and was looked upon as the leader of the game. The other four stones were termed the "*kai-mahi*," or common ones.

As many as ten players would sometimes take part in this game. First the operator would take the five stones in his right hand and throw them up; then quickly reversing his hand he would catch on the back of it as many as possible of the descending stones. Some will thus be caught and some will fall on the ground, where they are allowed to lie for the present. The *hai* is then taken in the right hand and thrown up. While it is in the air the player snatches up one of the fallen stones with the right hand and, holding it, catches the descending *hai* with the same hand. This is continued until all the fallen stones are picked up. This is termed "*takitahi*."

In the *takirua* the same process is gone through, save that two of the stones are snatched up at once.

In the *takitoru*, or third stage, it is the same process again, but three stones must be snatched up before catching the *hai*.

And in the *takiwha* four stones must be so snatched up. The next stage in the game is termed "*poipoi*." In this a mark is made on the ground—a straight line—on either side of which one stone is laid, these two and the *hai* being the only ones used. The *hai* is taken in the right hand and thrown up; then with the same hand one of the stones by the mark—the one on the right side—is taken and thrown up; then the descending *hai* is caught and thrown up again with the right hand; then the other descending stone is caught with the left hand and thrown up again. The remaining stone on the ground is thrown up by the left hand and caught with the right, and so on.

The next act is termed "*kōrōpu*." A small circle is marked on the ground, around the outside of which are ranged the *hai* and three of the other stones. The *hai* is taken in the right hand and thrown up, and before it descends the same hand must move the other three stones into the centre

of the circle, where they must be arranged so as to touch each other; the right hand then darts back to catch the descending *hai*, which it again throws up, and the right hand snatches up the three stones on the ground and then catches among them the descending *hai*; thus the right hand now holds all four stones. All motions of the *koropu* are performed by the right hand.

The final performance is the *ruru*. Three stones are laid on the ground; the *hai* is thrown up, then another stone is snatched and thrown up, then the descending *hai* is caught and thrown up again, then another stone is clutched from the ground and cast up, then the second stone is caught and thrown up again, then the *hai*, and so on until all the four are in use. But the *hai* must always be caught in the right hand and the other stones in the left.

When the common stones are lying on the ground together they touch each other, and the operator must be very careful in taking one away to throw up, for if he causes the other stone or stones to move in so doing, then he falls out of the game and another operator takes his place. It is quite a trial for the eye and hand to watch the descending stones so as not to miss catching same, and at the same time to take up one of the stones on the ground without causing any of the others which are in contact with it to move.

"When other villages hear that we are adepts at this game they will send a party over to challenge us to a game, and then interest runs high. Young men would always be eager to excel in games of all kinds, because they would then be admired by the girls."

The term "rehia," mentioned above, is now practically obsolete, and must be sought for in song and tradition. It is met with in Mr. White's volumes, and also occurs in the following:—

A Lament composed by Te Hou (Part only).

Ka riro i aku tamariki
Kai te rehia, kai te harakoa kari hika
Ko au anake i mahue nei
Hai tiakı pa ki Hiwarau ra
He keho koia e te ngutu poto
E whakaheke ra e te oi kau
Kei parea ki O-tarana
Kei mapu noa mai e tohe.

The seeker after the lore of the *whare tapere* will find some notes on the subject in the Rev. R. Taylor's "Te Ika a Maui."

Kati.—We will now cease, inasmuch as we have exhausted our stock of notes anent the diversions of the *whare tapere*, as obtained from the denizens of Tuhoeland. It remains for the compilers of the future to pick up the broken threads and

evolve a more complete description of the games and amusements of old.

* * * * *

The gleaming row of fires within the *whare tapere* have burned low down, the Children of Toi have dispersed, as we pass out again into the morn of the twentieth century, while the sliding-door closes behind us on the *whare tapere* for ever.

ART. V.—*Maori Magic: Notes upon Witchcraft, Magic Rites, and various Superstitions as practised or believed in by the Old-time Maori.*

By ELSDON BEST.

[*Read before the Auckland Institute, 7th October, 1901.*]

To the Maori of past days there were practically but three causes of death, as follows: (1) *Mate taua*, or death on the battlefield; (2) *mate aitu*, or *mate tara whare*, death from sickness—*i.e.*, a natural death; (3) *mate whaiwhaiā*, or death caused by witchcraft.

Deaths from *makutu*, or witchcraft, were, according to Maori ideas, exceedingly numerous in the days of yore, and still occur even in these times of the *pakeha*. Such deaths need not be the result of an active force, as in the *mātākai*, the *rua-iti*, &c., to be hereinafter described, but may also be brought about by what might be termed a semi-passive or a semi-active medium, which is not dangerous to life until it be interfered with. Of such a nature are the *waro rahui*, *rongo-takawhiu*, *pa*, and trees or places endowed with *tapu* in order to prevent persons interfering with them, &c.

There is also a third class or kind of *makutu*, or witchcraft, which is non-aggressive, and which is merely intended to ward off the magic spells of others, and protect the life, spirit, and physical and intellectual vigour of the performer. Of such a nature are the rites of the *mātāpuru*, *ahurewa*, *ngau-pae-pae*, &c.

Yet another variety is that which not only wards off and nullifies the effect of the magic spells of one's enemy, but also causes such spells to recoil on the performer thereof, and so destroy him or them. Such are the *kai-ure* and *ahi-whakaene* rites. These two latter varieties of magic are known by the generic terms of "*ripa*," "*parepare*," "*momono*," "*whiti*," and "*whakataha*."

After the above preamble I would wish to explain that the following notes on Maori magic comprise but a very small portion of the items of that extensive, far-reaching pseudo-science. For two reasons—first, such items, invading as they do all departments of Maori life, necessarily come under many headings, as "War," "Birth," "Marriage," "Death," "Woodcraft," "Social Life," "Sickness," &c. Hence to give a description of all branches of magic would be to compile a practically complete account of Maori life, and would result in an article of such appalling length that it would probably be returned to me with or without thanks. (See Skeat's "Malay Magic" as an illustration, and the review thereof which appeared in the London *Times*.) The other reason is that I have already described many of the items in papers prepared on different subjects, that on "War" alone running to some 250 pages of foolscap. Again, practically the whole of these notes have been obtained from the Tuhoe or Urewera Tribe alone, and hence the article makes no pretence of being a compendium of the magic rites of the Maori of New Zealand as a whole. Rites, customs, and superstitions differ to a certain extent among the various tribes.

It was Bastian who defined magic as "the physics of mankind in a state of nature." Moreover, it is quite clear to those who study the origin of religions, and also primitive cults, that the realm of magic must be invaded in either case in order to fully understand such cults and origins. Magic has ever been closely associated with religion. The Ark of the Covenant was the *mauri* of the Polynesian. The *hirihiri* of the Maori finds its counterpart in the bones or toe-nails of the mediæval gentlemen who struck work and declined to wash themselves. The *tawhito* and *kai-ure* beliefs yet linger in European lands. Do not laugh at the magic of the Maori; our houses are yet partially of glass.

Belief in magic was formerly universal with the Maori, and is yet believed in to a very great extent. *Tapu* and *makutu* were practically the laws of Maoridom. Property, crops, fish, birds, &c., were protected by them. The old-time Maori had to carefully guard himself against magic rites, against infringing the laws of *tapu*, for a hair of his head, a shred of his clothing, a portion of the earth whereon he had left his footprint would, in the hands of an enemy, be sufficient to bring about his death. In every walk of life, during every action, whether eating, drinking, sleeping, or taking his walks abroad, whether among friends or foes, if no enemy were within a hundred miles, yet death ever attended the Maori and walked side by side with him, awaiting the opportunity to strike him down and despatch his spirit to the gloomy underworld—the *Po*, or realm of darkness, of oblivion.

The ancient inhabitants of New Zealand are credited with having possessed the power of magic, as the story of Tama-o-hoi will show. This gentleman is also known as Te Mahoihoi, and is said to have been a past-master in magic—those forms of magic dangerous to life.

That strange person Tama-o-hoi was of the ancient people of this land. He was a descendant of Maui. His descendants are among the Maori people, and also the fairies who dwell upon the great ranges. Tama-o-hoi lived at Te Roto-iti, but his dwelling-place was underground.

There are three legends anent the feats of Tama-o-hoi or Te Mahoihoi: One occurred in the far-back period when mountains were gifted with the faculties of speech, locomotion, &c.; another just after the arrival of the canoe "Te Paepae-o-Rarotonga" from Hawaiki; and the third when "Te Arawa" canoe arrived.

In regard to the two names applied to our wizard, it is probable that Te Mahoihoi is the more correct, for this reason: This ancient personage is spoken of as an *atua*, or demon—a being possessed of supernatural powers. Now, in the Paumotu dialect "*mahoi*" means "a spirit"; in Tahitian "*mahoi*" means "the essence or soul of a god." Among the New Zealand branch of the Polynesian race Te Tini-o-te-mahoihoi is a name applied to an apparently mythical people —spirits, elves, or fairies similar to Te Tini-o-te-hakuturi and Te Heketoro. Therefore Te Mahoihoi is probably correct.

In the days of yore the mountains grouped around Taupo Lake were very numerous. They lived together amicably for some time, but when Tongariro took unto himself two wives—Pihanga and Ngauruhoe (two mountains)—then dissensions arose, and the mountain family broke up, many leaving the district. Taranaki went to the west, and some went east, including Whakaari (White Island), Paepae-aotea (an islet off White Island), Mou-tohara (off Whakatane), Putauaki (Mount Edgecumbe), and Kakara-mea (Rainbow Hill, at Wai-o-tapu). Putauaki had two wives, Whatiura and Pohatu-roa (latter at Atiamuri).

Now, Rua-wahia (mountain) was coming along all the time. And there was a certain demon coming from the east. That demon was Te Mahoihoi. He was the person who had great knowledge of magic. The two met and quarrelled. Rua-wahia struck at Te Mahoihoi, who warded off the blow and struck back so stoutly that Rua-wahia was cleft in twain, as may be seen to this day. Look at Tarawera. Look at Ruawahia.

Such is the earliest feat of Te Mahoihoi on record. The name Tama-o-hoi we will drop. It appears to be used by the

modern migration of the Maori, those whose ancestors came in "Te Arawa," "Mātātua," and other vessels. The former and correct term is used by the descendants of the ancient people of New Zealand—*i.e.*, of the Bay of Plenty tribes, the descendants of the old-time peoples known as Te Hapu-oneone, Te Tini-o-toi, Te Kotore-o-hua, Nga-potiki, &c. These latter are the people who have preserved many ancient Polynesian words not found in our Maori dictionaries, but many of which may be found in the dialects of Paumotu, Tonga, Mangareva, Rarotonga, Nukuoro, &c.—more especially such sacerdotal terms as "*mahoi*," "*puri*," "*tŭrŭma*," &c.

We give a genealogy from Tangotango to Te Mahoihoi, but have not secured the generations from the latter to the present time:—

Tangotango
Kopu-nui
Te Ata-tu
Te Marohirohi
Hikohiko-o-te-rangi
Te Tuhi-o-te-rangi
Paeroa-a-rangi
Te Rangi-a-tu
Tu-hikitia
Tu-hapainga
Tamarau-apu
Tapu-ariki
Tama-ewa
Te Mahoihoi-o-te-rangi.

We commence again. Rua-wahia is the mountain that was interfered with by Te Mahoihoi. That was before the vessels arrived (*i.e.*, "Te Arawa," "Mātātua," &c., the modern fleet of the fourteenth century). Waitaha-ariki-kore had arrived. His vessel was "Te Paepae-ki-Rarotonga." It came to land at Tara-o-muturangi, near Mătătā. Waitaha went to Rua-wahia, where he met Te Mahoihoi. The latter looked at Waitaha and saw that he was a stranger, whereupon he commenced his magic spells, in order to slay him. But Waitaha proceeded to avert the evil spell; he raised his incantation, it was the *tawhito*, the *whakakuruki* :—

Whakataha ra koe
E te anewa o te rangi e tu nei
He tupua, he tawhito to makutu
Kei taku ure e patu nei
Na te tapu ihi, na te tapu mana
Takoto ki raro ki to kauwhau ariki
Kuruki whakataha
Tau e patu ai ko koe ano
Haere ki te Po uriuri
Mau ka oti atu, oti atu.

Then the eyes of Te Mahoihoi weakened (*momohe*), and he

fled to Taupo, to Taranaki; hence the people of those parts are versed in the arts of magic.

In the above account are used some most singular expressions, which, when inquired into, lead us into various interesting channels of research. My aged informant said, "*Te Mahoi-o-te-rangi, te tangata tena nana te makutu. He tama-tane tena mahi a te iwi Maori, e kore ia e kaha i te tama-wahine*" (Te Mahoi-o-te-rangi was he who practised magic. That practice of the Maori people was a *tama-tane*—male child, or son; but it cannot contend against the *tama-wahine*—female child, or daughter). Here "*tama-tane*" seems to be a term applied to witchcraft, active magic, while the expression "*tama-wahine*" denotes defensive magic. I have nearly one hundred notes collected on these two expressions, and they appear to be applied to everything in the heavens, on earth, and the waters under the earth. It would take up too much space to go fully into the matter here. *Tama-wahine* is applied to the west, sometimes to the north, and to the *ruahine* who performs the closing act of all sacred rites—that is to say, the lifting of the *tapu* or sacredness—also to descent from Papa, the Earth Mother (the female line of descent), and to numberless other things.

Here is another remark of my venerable authority. In speaking of Te Mahoihoi's encounter with Waitaha he continues: "*Ko taua waha a Te Mahoihoi, he waha rawhiti. Ma te tawhito anake a Waitaha e kore ia e ora, ahakoa waha rawhiti, waha hauraro, tama-wahine. Ka hu i te tama-tane, ka ora te rangi, ka ora te iwi*" (That voice of Te Mahoihoi was an eastern one. The *tawhito* alone could not have saved Waitaha, albeit an eastern or northern voice, or the *tama-wahine*—(?)west. When the thunder resounds in the *tama-tane*—east—then the sky clears and man is safe). Here are more side issues. The latter part of the remark refers to *oho rangi*, a rite performed by the priests (*tohunga Maori*) in reference to certain sacred matters, in order to cause thunder to resound. The term "*tawhito*" is practically the same as "*ure*" (membrum virile). The latter is the ordinary term, while the former is the sacred or sacerdotal term, and which may be translated as the "Ancient One." It was used when referring to the organ as being used in various rites, as to ward off evil, especially magic spells. "The *tawhito*," said one of my aged teachers, "is the salvation of man." But more of this anon.

After a perusal of countless notes I have evolved the following. I fear it is not a clear formula, but appears mixed and vague; but there is something of great interest behind these ancient, dim, and metaphysical abstractions:—

1. *Tama-tane* = *waha rawhiti* = east = male descent, and *tawhito* active, and active magic.

2. *Tama-wahine*=*waha hau-raro* = west = female descent, and *tawhito* passive, and passive magic.

3. In magic the latter prevails or is the most important, if backed by sufficient *mana* (power, prestige, intellectual, natural, and supernatural), *mana*, according to the Maori, being derived from ancestors.

4. *Tawhito* = *ure* = procreative organs.

Hence,—

5. *Tama-tane* = male = active force.

6. *Tama-wahine* = female = passive force.

7. Waitaha could not be saved by the male *tawhito* alone. It needed a blending of the *tama-tane* and *tama-wahine* (male and female forces) in order to preserve life. In like manner, when both the *tama-wahine* and *tama-tane* thunders have resounded, then the sky clears.

The whole being the results of the attempt of a primitive people to explain the male and female forces, and to apply such to all departments of nature. And probably these items are the remains of, and point to, a system of phallic worship, as practised by the ancestors of the Polynesian race in times long passed away.

Kai Ure.

The rite known by the above term is performed in order to save the life of a person who has been subjected to the magic spells of an enemy, and to cause such magic to recoil upon the author thereof. *Ka rere te ringa ki te ure, ka titoiria, katahi ka hapainga te karakia*:—

> Kai ure nga atua,
> Kai ure nga tapu,
> Kai ure ou makutu, &c.

And, again, in the *whakau* rite the following is repeated:—

> To kai ihi, to kai ihi
> To kai Rangi, to kai Papa
> To kai awe, to kai karu
> To kai ure pahore, &c.

In speaking of the above rites an old Maori said to me, "The *ure* is the important *mana* (power, prestige, &c.) of the *tapu*." An interesting *kai ure* invocation may be found in "Nga Moteatea," page 305.

An aged native wrote me, saying, "Friend! I am sending the means by which you may ward off the shafts of magic and confound your enemies. Behold this invocation, the *tawhito*, the *kai-ure*, which saves man. When a person attempts to interfere with you in any way do as I tell you and you shall retain life; but your enemy, he shall descend to Hades for all time." He then proceeded to explain how I

was to act, and also wrote out the magic spell. I have not yet tried it on any of my enemies, but hope to be able to do so in the future. This subject is an extremely interesting one, but my notes thereon have really become so numerous that they must be reserved for a separate paper.

It is said that the Takitumu migrants brought a great knowledge of magic with them to New Zealand.

One of the most common forms of *makutu*, or witchcraft, is that in which a medium is used in order to connect the spells of the wizard with the object to be acted upon by them. This medium, termed "*ohonga*" and "*hohonga*," when man is the object, is usually a fragment of his clothing, a lock of his hair, a portion of his spittle, or a portion of earth on which he has left his footprint. By obtaining such a medium the wizard will be able to bewitch the owner thereof by uttering his spells and performing certain rites. This is sympathetic magic. It may work all right, but if the object becomes aware that arts of magic are being practised against him he can divert (*whiti*, or *whakataha*, or *ripa*) such by counter-spells and rites, as the *kai-ure*, the *parepare*, the *momono*, and many others. It will then be resolved by the fact as to which possesses the greatest *mana* or power (intellectual and supernatural).

The above is generally termed "taking the *hau*" of a person. The *hau* of man means his intellectual and spiritual and supernatural power (*mana*). The *hau* is the immaterial essence or representation of such powers, while the *ohonga* is the material representation of the *hau*, and through such medium the *hau* of the subject is affected. When a person's *hau* is affected by magic his body perishes, it can no longer exist; his intellectual and spiritual force has departed.

If you meet a wizard, a person famed for his magic spells, and you happen to be carrying some food, do not give him any of it or he will use it as a medium and bewitch you. But when he has passed you do you stop and wave that food across the track, and repeat an incantation to nullify the effects of his spells. The action of waving the article of food across the trail traversed by the magician will carry with it the "warding-off" power of the *karakia* or charm.

When the *ohonga* is taken it is fastened to a branchlet of the karamuramu shrub and taken to the *tuāhu*, or sacred place of the village, and there the necessary spells are repeated over it in order to cause the death of the subject, who will be afflicted by wasting sickness.

If you are talking to me and I wish to lay a spell upon you, I can take the *hau* of your voice by uttering certain incantations. Such spells as this and others practised in the presence of the subject are not repeated aloud.

The earliest case of slaying a person by magic contained in my notes is the destruction of Maui by Hine-nui-te-po, Goddess of Hades (the *Po*) and personification of death. The origin of the quarrel was the slaying of the children of Mahuika (origin and personification of fire) by Maui. After that Maui and Hine differed as to whether or not man should grasp eternal life. The *ohonga*, or medium, obtained by Hine was a drop of Maui's blood, which Namu, the silent sandfly, procured for her. The mosquito was sent first, but proved to be too noisy a messenger, and was heard and killed by Maui. Verily it was well to be wary in the days of old, for death was ever near.

There were many ways by which personal *hau* might be protected from magic, so long as the enemy's magic was not the more powerful. For instance, the *ahua* or semblance of the *hau* of man could be taken and protected by means of magic. The material token of such semblance would probably be a lock of the person's hair. This would be taken to the *tuāhu*, or sacred place of the village, and buried at the base of the *Ahurewa*, which is one of the forms of *tuāhu*, and is represented to the eye by a carved stick stuck in the ground. The depositing of this talisman was accompanied by the repetition of appropriate incantations or spells to render it effective.

A similar thing was the *ika purapura*, or *taitai*. This was a bird into which the semblance of the health, vitality, vigour, productiveness, &c., of the people and tribal lands had been instilled. After being hung up for a time, this talisman or semblance of the *hau* of man and land was buried, as an *ika purapura*. It would retain the essence of the desirable qualities of man and land, and guard them against magic arts. For reasoning in a metaphysical and anagogic sense the Maori has probably no superior, so far as his understanding went.

The *hau* of land, or of a forest, or of a productive tree, can be protected in the same way as personal *hau*, and in much the same way, by the concealing (with proper charms or invocations) of a material semblance of such land, forest, or tree. Take, for instance, a tree which is much frequented by birds, and hence a desirable one on which to set bird-snares. It is deemed advisable to protect the tree from being killed or blasted by an enemy's magic, or the birds driven therefrom by the same means, or from being poached by other persons. Therefore the tree is made *tapu* by the priest; after which, should any one interfere with it, such person will be afflicted by the *atua* or familiar demon of the priest. If that person, so afflicted, wishes to save himself he must go to the priest or wise man who rendered the tree *tapu* and place himself in

his hands for treatment. Nor is it wise to delay the matter; the gods who live for ever are not to be trifled with.

In the above rite the priest takes the *hau* of the tree, or the semblance thereof. The usual plan is to take the first bird snared upon the tree—or the long wing-feathers (*kira*)—which is taken away and hidden in the forest somewhere, and incantations said over it to render the tree *tapu* and so protect it. It cannot now be injured by the magic spells of enemies.

Should a person sell or barter the property of another, that is termed a "*hau whitia,*" or "averted *hau.*" The person who so received the article will surely die; he will not survive.

Theft was often punished by the dread arts of magic in this wise: When a person lost an article by theft he would take the *ahua* (semblance of personality) of such article to the priest, the material token of which *ahua* would be something that had been in contact with the stolen article. Two cases came under my notice. In one some eels were taken from a man's eel-pot. In the other case money was stolen from a box. In the first case a fragment of the eel-pot was used as a material token of the personality of the eels. In the other a coin which had been overlooked by the thief was used. This medium would be taken to the priest and laid before him, with the explanation that it was the *ahua* of an article which had been stolen. The priest would look at the material medium and say to the applicant for justice, "I see the *wairua* (spirit) of the thief standing by your side." He would then describe the appearance of the thief whose spirit he saw. Such spirits are always anthropomorphous with the Maori, and probably to all other primitive races. The plaintiff in the above case would, when he recognised the thief from the priest's description, sometimes go and demand his property so as to give him a chance of escaping the awful effects of the priest's spells of witchcraft. When the thief refused to return the article stolen it was time enough to put the law of *makutu* in force. Sometimes, however, the sufferer of the theft would say at once, "*Patua atu*" (Destroy him). The priest would then perform his magic rites over the medium which had been brought to him. And it was not well for that thief; death or insanity lay before him. The priest who performed the above rite would be one of the class of *tohunga* (priests) known as a "*tohunga ruanuku.*" Other classes of priesthood are *tohunga taua,* or war-priests; *tohunga pukenga,* or teachers; and *tohunga puri,* who are also magicians. The above priest would also be a *matatuhi* (*matakite*), or seer. The material medium mentioned above is sometimes termed "*hau*" or "*maawe.*"

When it comes to the knowledge of a person that he is under the influence of magic directed by some enemy, or when he is taken ill, he at once hies him to the priest, who will tell him to return to him in the evening. When the sun sets they go together to the *wai tapu*, or sacred water of the village. This is a pond, spring, or stream set apart for sacred purposes, and no one may interfere with such water or make use of it. To take a drink of it is about equal to taking a dose of poison; it is even dangerous for an individual unaccompanied by a priest to approach it. On arriving at the water the priest looks at the patient and says, "You have been bewitched. I see the wizard standing by your side. What shall I do with him?" The answer will probably be, "Slay him." The priest then repeats the spell to destroy the wizard, after which he taps the patient with his sacred wand and recites:—

> To ara
> Haere i tua, haere i waho
> Haere te maramatanga
> Haere i nga kapua o te rangi
> Haere mahihi ora
> Haere i nga kapua o te rangi
> Haere ma hihi ora
> Ki te whai ao, ki te ao marama
> Ko rou ora
> Haere i a moana nui
> Haere i a moana roa
> Haere i a moana te takiritia
> Ki te whai ao, ki te ao marama
> Ko rou ora.

With his wand the priest sprinkles water over the body of the patient. At dawn next morning the sacred *umu*, or steam-oven, is kindled, and food cooked therein. Among the food is a special piece placed. When the oven is uncovered if that special article of food is thoroughly cooked, then it is known that the wizard has perished or is nigh unto death. Then the patient recovers. It would appear that the above may be a form of crystallomancy, and that the priest, by intense will-power or other means, sees reflected in the water the form of the magician—*i.e.*, if the acting-priest's *mana* is strong enough to overcome that of the offending wizard. Such rites as the above are always performed in the evening or early morn, for the simple reason that the *wairua*, or spirit of man, does not wander forth or roam about in the broad light of day, and hence is not available to be influenced by the magic spells of the priest. In like manner, when such a rite is being performed the people of the village or fort will remain in their houses, lest their spirits roam forth and approach the spot where the magic rites of the priest are being performed, which would probably destroy such wander-

ing spirits, when, of course, the physical bases of such would infallibly perish.

Those who have been simply rendered insane or mentally deranged (*keka*) by magic for such a crime as theft would spend the balance of their days wandering aimlessly about, clutching at the air, and repeating meaningless words and phrases.

WHAKAMATITI.

The *whakamatiti* is a spell of magic, or magic rite, which is employed by a priest in order to punish a thief without killing him. This causes him to become mentally deranged, as described above, and also contracts his fingers and weakens his hands, so that he can take or hold nothing with them. This rite is sometimes termed "*ahi matiti.*" It is mentioned in an *oriori*, or lullaby, of olden times :—

Waiho te whare, E hine!
I to tipuna i a Paia
Hua rawa atu nei ka matau rawa i a ia
Te whata a to tipuna, a Raumati-ninihanga
Para whetau—e
Na Turuwhatu te whata a Pouroa
I Tahuna-a-tapu.
Mou ra, E hine!
Koi hikaia koe ki te ahi o te ruhi,
Ki te ahi o te ngenge,
Ki te ahi o te whakamatiti
Mo te kore rawa, E hine!

There were in former times a great number of charms or spells of an inferior kind, which had no power to destroy life, but simply unnerved or weakened the subject. They were often put in the form of a song or chaunt (*waiata*). The following is a specimen thereof. It is one of the class of songs known as a "*makamaka kaihaukai,*" which are chaunted by the people who present food to guests at a feast. The following was composed by one Ruru, of Tuhoe, in order to unnerve a rival and render him incapable of performing with good effect before the visitors at a feast :—

He Waiata Makamaka Kaihaukai. Na Ruru: He Karakia kia kore e kaha tana hoa Makamaka Kaihaukai, kia hinga i a ia.

Korokoro whiti, korokoro whiti
Tu ana te manu i runga i nga puke ra
Tenei hoki te kame ka whakairi
Te kame ka whakarere
Te kame i pokaia noatia
I runga i a Tu-ka-riri
I a Tu-ka-niwha, i a Tu-ka-ritarita
E haere ana Rita, he tangata kamenga kore
Ka pau te ki hanga maka
He nui kame maoa e tu ana i ou atua roa
He tini te kame, he mano te kame, he tutae taua
Ka kame tiko iho ki waenga

He aha aku kai tē pau noa ai
Naku te tohenga ki te whitu, ki te waru
Ki te roa o te tau
Waiho nei matau hai timokomoko kai
Ma te ngahuru (? Ngahuru)
Tangi ana te whakatopatopa o kame
O kame maunu, he toroa, he taiko—e, &c.

The following is also a charm to weaken a person and prevent him from finishing the building of his house. It might be used out of ill-will, or to punish the builder for having made an error in the plan of the house or in the measuring (*tieke*) thereof :—

He tai panuku, he tai wheranu
E Nuku! E moe nei, ka riri koe e koe
E Papa e moe nei
Tauia mai ra te papa o toku whare
Ko Hauhau-tu-ki-te-rangi
He ra ka hinga, he ra ka newha
Ka tupeke hinga ki tai o Motutapu (or Ka tupe, ka hinga ?)
Uahatia taku manu i te rangi
He toroa, he karae, he taiko
Ko te manu tangi reo
Ki te muriwai o Wai-rarawa
Turakina, ka hinga ki te Po whekerekere
Ka takoto i Muriwai whenua
Ka eke i ona irohia.

There are two varieties of charms or magic spells known as "*rotu*." One is termed a "*rotu moana*"; it is used in order to calm the ocean—to put it to sleep, in fact. "*Rotu*" means "heavy-eyed," as for want of sleep. "*Rorotu*" means "to oppress with sleep." The other *rotu* is used in order to make a person sleep. The following is such an one :—

E moe! E moe!
Ko te po nui, ko te po roa
Ko te po i whaka-aua ai to moe
E moe!

Tamoe, or Umu Tamoe.

"*Tamoe*" means to suppress the evil designs and enmity of people by means of a magic rite—the *umu tamoe*. When the Matatua immigrants were coasting along the shores of the Bay of Plenty they performed this rite before landing, in order to calm the enmity of the people of the ancient tribes of that part. After a battle has been fought the victors perform the *umu tamoe* in order to prevent the enemy being able to avenge their defeat. The *umu horokaka* is a rite performed before attacking an enemy. A fire is kindled by the priest, whose magic spells are to cause the *wairua*, or spirits, of the enemy to be drawn into the magic fire and therein be consumed (*ka rotua nga wairua o nga hoariri ki roto*).

The *umu hiki* is a rite performed in order to cause a people

to forsake their lands and migrate to pastures new. It is an easy way of disposing of objectionable people.

The *ka-mahunu* is a rite performed in order to render an evil person ashamed of his ways—to cause his conscience to prick him, in fact. This is probably one of the highest points to which Maori ethics reached.

The *wero ngerengere* is an incantation to cause a person to be attacked by leprosy. It is a Taupo product, and used to be practised there.

Tu-matapongia is a spell to cause a person to become invisible to others. It is useful when being pursued by an enemy.

The *papaki* is a spell to destroy or render demented a woman who will not consent to marry a man who desires her. There are many charms and magic rites in connection with birth, love, marriage, conception, divorce, &c., which would occupy too much space here.

The *hau-o-puanui* is a wind raised by magic in order to accelerate a person's speed in travelling, or the return of a truant wife, &c.

The *whakamania* is to pass disparaging remarks about a person to his face, not behind his back, to which latter the terms "*kohimu*," "*ngau tuara*," "*rae oneone*," &c., are applied. The term "*whakamanioro*" is similar in meaning to "*whakamania*." These disparaging remarks, when uttered by a person of importance, are looked upon as being ominous of evil. When the sons of Tuwharetoa, of Kawerau, wished to go a slaying their aboriginal neighbours their father objected, and told them to wait until the *tapu* was lifted from his crops. However, the sons persisted, which angered the old gentleman. He said to them, "*Haere i a tuku noa, i a heke noa, e popo, e anea, mau ka oti atu, oti atu*," which was equivalent to telling them that they could go to the deuce and end in Hades. So fell they in the fight of Kaka-tarae.

The *umu-pururangi* is a rite and incantation used to destroy life. When the two wives of Uenuku-koihu quarrelled one slew the other by means of this magic rite, which I refrain from publishing, for obvious reasons.

The *puru-rangi* is an incantation used to block up the flood-gates of the heavens, in order to make the rain and wind cease and bring fine weather. It is an extremely useful charm to have in camp. When winds become too boisterous to be pleasant the first invocation or spell repeated was the *tokotoko*, which was to cause the wind to betake itself to other parts. After that the *puru-rangi* was recited:—

Tokona nga hau
Tokona ki waho
Tokona nga hau
Tokona ki uta
He rangi kia purupurua, &c.

The wind known as "*tutakanga-hau*" is laid by means of cursing it vigorously, as follows :—

Pokokohua!
Poko-ko-hua!
Riri—e! Riri—e!
Riri te rangi i runga nei
Riri nga hau.

The *umu-pongipongi* is also a rite of magic used in order to take human life (*he umu kai whanaunga*). Compare *fakabogi* = murder, in Tongan, as also *fakabogibogi*.

A strange legend of Te Roto-iti mentions a horde of demons or uncanny objects which were despatched by Te Rongo-pu-iti against the Moturoa Fort at that lake. These *taniwha*, or goblins, appeared in most extraordinary forms, such as *he uma kau* (a being all chest), *he upoko anake* (a head only), *he tapahu* (war-cloak), &c. I much fear that the seer who saw these wondrous beings must have been unwell at the time. However, the Maori priests and mediums had some very extraordinary hallucinations.

Ahi Whakaene.

This was a rite by which many different spells of magic were performed in the good old days. It is said to have been a sacred fire kindled by a priest, and over which the *ka-mahunu* and other rites were performed.

A rite is performed at the *ahi whakaene* whereby the personality (*ahua*) or the *hau* (intellectual and spiritual force) of man is destroyed, when the body of such man must perish. When the priest kindles the sacred fire he repeats the following charm, known as *hika ahi* (fire-generating):—

Hika atu ra taku ahi, Tu ma tere
Tonga tere ki te umu toko i-a-i—e
Tere tonu nga rakau
Tere tonu ki te umu—e.

Another rite performed at the *ahi whakaene* is that known as *whakautuutu*. To encounter the *moko kakariki*, or green lizard, or the *moko tapiri* was an evil omen. The person seeing one in his path would at once know that it had been sent by an enemy to destroy him and possibly his clan also. Such an occurrence is termed a "*kotipu*." The first thing to do in such a case is to kill the reptile and get a woman to step over it, in order to avert the omen. This is called a "*ripa*" or "'*whiti*." The people then collect to perform the *whakautuutu* rite. The priest kindles the *ahi whakaene*, and the reptile is cut into pieces, which are thrown into the fire. As each piece is thrown in the name of a tribe, or sub-tribe, or noted magician is mentioned: "So-and-so shall eat you"—mentioning all people whom it is thought likely

might have sent the ill-omened reptile. Also a charm known as "*hirihiri*" is repeated, in order to banish the threatened disaster to other parts. Then the people will pull out some of the hair of their heads and cast it into the fire, and all expectorate upon the dead lizard. Thus will the evil omen recoil upon he or they who sent it. *Kaitoa !*

> I tahuna mai ahau ki te ahi whakaene
> Ki mate te wairua.—OLD SONG.

The *hirihiri* is repeated by a person when he believes that some one is directing, or may shortly direct, spells of magic against him. Also, a priest will recite a *hirihiri* over a sick person, in order to discover who is "meddling" with him—that is to say, what magician is bewitching him. The following is an example:—

> Kotahi koe ki reira
> Kotahi kia Te Reretautau (name of a priest or magician)
> Kotahi koe ki reira, kotahi ki nga ariki
> Kotahi koe ki reira, kotahi ki nga mātāmua
> Kotahi koe ki reira, kotahi ki nga wananga
> Kotahi koe ki reira, kotahi ki nga tapu
> Kotahi koe ki reira, kotahi kia Te Haraki.

In the particular case from which I take the above, when the patient heard the name of Te Haraki (a wizard) pronounced his life departed in a last sigh (*puhanga manawa* = the last expelling of breath by a dying person). Thus it was known that the worker of magic, Te Haraki, had been the cause of his death. Had the illness of the sick person been caused by that violation of *tapu* known as "*kai-ra-mua*" (the eating of food set apart for the first-born, *matamua*, of a high-born family, a most intensely *tapu* individual), then he would have expired (*ka puha ake te manawa*) at the word *mātāmua ;* and so on with the other terms.

Be clear, the offender would be afflicted in this manner during times of peace. But if he ate of the food of a *mātāmua* in time of war, then he would be afflicted by *Tu-mata-rehurehu* of dread memory; of a verity the afflictions of the *pahunu, hinapo,* and *parahuhu* would descend upon him. His strength would wane, his sight wax dim, no enemy would he slay or catch, the fear which springs from sin committed would be upon him. All of which troubles are inflicted by the gods.

NGAU PAEPAE.

A person falls ill. The priest is sent for. He finds that the illness has been caused by some infringement of *tapu*. The priest will then proceed to cure the patient by means of the rite known as "*Ngau paepae.*" He conducts him to

the village latrine, and says to him, "Bite the *paepae*" (wooden bar), which the patient does, the priest reciting :—

Ngaua i te pae, ngaua i te wehi
Ngaua i te upoko o te atua
Ngaua i a Rangi e tu nei
Ngaua i a Papa e takoto nei
Whakapa koe ki te ruahine
Kia whakaorangia koe
E tahito nuku, e tahito rangi
E tahito pamamao
Ki Tawhiti i Hawaiki.

The following is another such *karakia* (charm, spell, incantation, invocation) :—

Ka kai koe ki tua
Ka kai koe ki te paepae
E takoto nei
Koia nga tapu, koia nga popoa
Koia nga whare, koia nga urunga
Koia nga tapu nei
He atua kahu koe
Haere i tua, haere i waho
Haere i te rangi nui e tu nei
Mahihi ora
Ki te whaio ao, ki te ao marama
Ko rou ora.

After this rite the patient is *noa*, or free of the dread *tapu*, and so recovers.

Matakai.

The *mātākai* is a spell recited in order to bewitch a person while he is in the act of eating, that the food and power of the spell may pass together into his stomach. In two days he will be assailed by illness. (See an account of the same sort of magic in Welby's travels in Abyssinia.) It is said by some that this spell causes a person to choke; he cannot swallow his food, it sticks in his throat.

Tangi Tawhiti.

This was a spell of magic in the form of a chaunt or dirge. It was used in order to slay a person or persons sometimes living far away. The following is a *tangi tawhiti* composed and chaunted by the Tuhoe people in order to avenge the death of Te Umu-ariki, one of their chiefs who had been slain at Whangara :—

Tangi taukuri ai, e te mamae ra
Takaro ra mota ki whakaaro iho
Koia te tangata ringa taupoki patu kohuru
Ko tama e tu, ko Rehua tu roa
Rite rawa iara te toa taurekareka
Whakaorahanga ki te ra, ki te marama
Nou te kaha ki te ika tere
Ka pae kai a Matioro

Turanga o te tipua o Paoa, o Takitumu
O Ruawharo, o Timu-whakairia, o Rongokako
Ka mene kai roto o te puku nui o Tahaia
Aurara ou ringaringa, kai te rokiroki
Kai te penapena, kai te rakai whenua
Tetea nga niho o Tara-mai-nuku
Te niho o Tipoki ka whakatara ki te whetu
Te niho o Tipoki ka whakatara ki te marama
Ona niho kai tangata
Ka ngau ki te mata o Hoturoa
Ripia mai nei e te *paea*
Te taha maui ki tana (ripi)
Te Tipi a Houmea ki te one poutama
Tena te tohu na te tipua
Ka mau kai te kiri o te toa horopu
He ringa kia tu
Ka maha noa atu e roto—i.

The *tipi a houmea* mentioned above is identical with the *papahāro*, a most grievous affliction. It is a rite of magic which is used to blast the fertility of lands and render them sterile, or to destroy shellfish, &c., on a beach. The performing priest smooths a little sand or earth, which represents the lands whose fertility is to be destroyed. He then scores it across with a wand, repeating at the same time his spell of magic to blast the fertility of that land. Or he will take a stone and recite over it his spell, and then throw the stone across the land or water to be sterilised. It is the *mănă* of his ancestors, whom the priest invokes, that is the destructive power. The incantation to restore the good products of such lands to their original state of vitality is known as "*pare-hao-kai.*"

The following is an interesting *tangi tawhiti:* A female relative of Piki, of Tuhoe, was bewitched by Taratoa. Piki, who was at Whakatane, chaunted this *tangi tawhiti* in order to slay Taratoa, who, with all his people, was living inland. Taratoa saved himself and two relatives by means of countercharms, but the rest of his relatives died :—

E hine, Marunui i te tapui
Ka taka i ou tuakana
Tu ake hoki, e hine! I te tu wharariki
Hai whakakakakara mo hine ki te moenga
Te moenga tē whita, te moenga tē au
Oti tonu atu koe ki raro—e—e
Taupae atu ra i tua o Te Wharau—e hine!
Ka wehe ko te po, ka wehe ko te ao i a koe
Tokona atu ra ki tawhiti
He tokouri, he tokotea, he mapuna, he kai ure
Kai ure noa ana, e hine!
Nga tohunga i nga atua kia mate
Koi tonu nga niho ki te ngau.
Na Maui i hangarau, e hine!
Tana ika tapu, ko te whenua nui
E noho nei taua

I tikina ki raro wheuriuri, kia Hine-nui-te-Po
Hai ngaki i te mate
I tukua mai nei ki āna karere,
Ki te waeroa, ki te namu poto
Hai kakati i te rae.
I te mata o te hurupiki—e hine!
Ko ta paua (?) ka ea te mate
O te hiku rekareka nei, o te tuna—e-i
Takoto mai ra, e hine!
I roto i te whare papa
Ko te whare ra tena o to tipuna, o Tama-a-mutu,
I tuhia ai—e-ki te tuhi marei kura
Koia a Ngai-Tama-tuhi-rae
I whakairi ai—e-ki runga ki te rakau
Koia te kauhau i to papa, i a Maui, e hine!
Tera ia te rua o tini raua ko mano
I karia ki te oneone ika nui—e hine!
Hurihuritia iho ra, e hoa ma—e!
Ta tatau mahuri totara
No te wao tapu nui a Tane
No te awa-e-i Oatua
No runga-e-i Okarakia
No nga pinga-e-i roto i te Kopua
Taku totara haemata,
Te rite ai, e hine!
Ki a koe—i—a.

Oatua is a stream and Okarakia a settlement at Ruatahuna. The *tuna* mentioned is Puhi, the eel-god, who was slain by Maui for interfering with Hine-nui-te-Po, Goddess of Hades.

The Maori possessed spells of potent magic to contract the land, and others to stay the sun in its course. These were used by travellers. Others were used by persons engaged in searching for anything. If a person were supposed to have been slain or perished from hunger or in a snowstorm while travelling, a priest (*tohunga ruanuku*, or magician) would perform a certain rite in order to "awaken" the bones of the dead—*a ka hu mai aua wheua*, and the bones would resound to show their whereabouts.

The *punga* was a spell to lessen the speed of a person pursuing one, or of a person one is pursuing.

The hearts of slain enemies were cooked at a fire termed "*ti-rehurehu*," and spells were repeated over them to sap the bravery of the enemy and render them faint-hearted.

The *whakaumuumu* is a magic spell used to destroy human life. To ward off a threat of magic the following brief phrase is used: "*Kuru ki whakataha.*"

If a person is put to shame before people he may wish to be transported elsewhere. He will therefore call upon his familiar *taniwha*, or monsters—probably ancestors of his, who assumed that form at death—to bear him hence. He will summon them by repeating the following:—

Tangi atu au ki te ninihi nui o te moana
Ki te parata nui o te moana
Ki te taniwha nui o te moana
Ki te paikea nui o te moana
Kia hara mai, kia horomia hine
Ko Hine whakaruru taua
Kei a rawea e koe
Tutakina ki te rangi taua.

The *toko-uri* and *toko-tea* are said to be two posts or sticks which are erected at the sacred place of a village. One is the emblem of misfortune, sickness, and death; the other is the emblem of health, vigour, and life. The one is subjected to magic rites that misfortunes may not assail the tribe—to expel sickness, death, &c. The other is similarly treated to cause it to retain the health, vigour, &c., of the tribe.

It is excessively bad form to be inhospitable to a visitor. Should he arrive while you are eating, ask him at once to join you. Should you neglect so to do, thinking, perhaps, that he is a person of low birth and an ignorant, yet he may possess powers of magic and destroy you for slighting him. Hence the old saying, "*Kai ana mai koe he atua, noho ana ahau he tangata*" (You are eating there as a god; I am sitting here as a man).

When red war has siezed upon the land it is quite probable that you will find yourself, spear in hand and *patu* in belt, about to measure strength with an enemy; or trouble may arise in other ways, and it is decided that you settle the matter by single combat. You first carefully perform the rite of *tuaimu*, and repeat the spell or incantation known as a "*mata-rakau*" or "*hoa rakau.*" This has the effect of rendering a thrust or stroke of your weapon most effective. Before you commence to repeat the charm you must spit upon your weapon. If you wish to kill your adversary you add the words "*Mau ka oti atu ki te Po, oti atu*" (Away to the shades for ever) to your *tuaimu* spell which is meant to weaken your enemy. But, if your adversary is a relative, you probably do not wish to slay, but merely to wound him. Therefore the above words are omitted, and when you have struck down your foe you stand over him, and, expectorating upon your fingers, rub them over the face of the fallen man, at the same time repeating: "*Mau ka hoki mai ki te ao nei*" (Return you to the world of life). Understand, you yourself are under *tapu* at this time, and therefore your spittle even is, as it were, impregnated with that *tapu*. Therefore the action just described has the effect of imparting *mana*, or power, to your magic.

RUA-ITI, OR RUA-TORINO.

This is another method of destroying life by magic spells acting upon the human *hau*. Ngati-awa Tribe describe the

rua-torino as being a mound of earth formed in human shape by the priest. In this supposed human body he makes a hole, and then recites his spells of magic, in order to cause the spirit of the subject to descend into that hole, where it is affected or destroyed by the spells of the priest.

Tuhoe describe the *rua-iti* as follows: The priest makes a hole in the ground. This is the *rua-iti*. He has already obtained a piece of cord, the property of the subject, obtained by theft. He holds one end of the cord in his hand and allows the other end to trail down into the hole. He then repeats a spell to cause the *wairua*, or spirit, of the subject to descend the cord into the *rua*, or hole, where it is confined and destroyed by an incantation known as "*kopani-harua.*"

If a man finds out that some one is trying to destroy him by means of magic, his *atua*, or familiar demon (probably the spirit of his father or of an ancestor) will warn him, or his own *wairua* (spirit) will discover the fact that a magician is "meddling" with its physical basis and so return and warn the same (this refers to dreams: a person dreams that he is being so treated; to the Maori it is his spirit which has seen it); and he, the subject, will despatch a person to obtain a piece of any kind of cord belonging to the wizard. This cord is the medium between the subject (who now becomes an active agent) and the magician. The person makes an incision on his shoulder and smears the blood therefrom on the cord, which he then burns. I have not the special incantation here used. This rite is to ward off the spells of the magician who has bewitched him, and if it has sufficient *mana* it will destroy him. The performer must then *whakanoa* or lift the *tapu* from himself. To effect this he will obtain the services of a *ruahine*, a woman who is employed to make common people, houses, &c., under the influence of *tapu*. He cooks a single *kumara* and hands it to the woman, who eats it, while more invocations are repeated. Another way is to place the *kumara* under the threshold of his house, which the *ruahine* then steps over.

In war, when flying from an enemy, the pursued would turn and score a line across the earth or water behind him, at the same time repeating a *karakia*, which is said to destroy the pursuer so soon as he crosses the aforesaid line. When it was known or suspected that a war-party was approaching in order to attack a fort or village, the priest of the latter would go forth and bury a *kumara* (sweet potato) under the trail by which the enemy was supposed to approach. When such enemy crossed that spot they would be assailed by the *pahunu* or *mahunu*, a loss of nerve, an indefinable fear, produced by the spells of the priest recited when burying the *kumara*. Sometimes a spear would be laid across the track

with the same object in view. Of course, the *hoa rakau* charm was repeated over the weapon thus deposited.

In the far-back misty past, when gods and men mingled and deeds of passing strangeness occurred, it was Maahu who strove with Haere-atautu, their weapons being the magic of old. This was probably after the separation of Maru, Haere, and Kahukura. Both those beings were destroyed, each by the other. Haere (a rainbow god) was lured by Maahu to the *paepae*, where he was entered by Noke, the earthworm, and so destroyed; while Maahu of old was lured by Haere into the calabash known as Tipoki-o-rangi and therein destroyed.

When travelling through an enemy's country always walk in the water as much as possible, so as to avoid leaving your footprints on earth or sand, the *hau* (personality) of which might be taken by an enemy and used as an *ohonga*, or medium, through which to destroy you by his dark spells. Also be careful not to expectorate as you traverse a trail or cast away any article you have touched, for any of these articles may serve as a medium for the rites of magic. Again, when in mixed company, of whom you are not sure that a member thereof may not bear you ill-will, never rise from a seat without putting down your hand and "scooping up" therewith any fragments of your *hau*, or personality, which may have adhered to the seat. It is not well to neglect these precautions.

A priest or magician of sufficient *mana*, or power, can cause a flood by means of an invocation known as *tuku-rangi*, addressed to Para-whenua-mea, the origin and personification of floods or flood-waters. He can also cause a flooded river to subside. To do this he would take in his hand a stone, over which he would repeat his *karakia* (charm, &c.). He would then cast the stone across the flooded river. The *tohunga rua-nuku* had also incantations in his budget wherewith to blast trees, to shatter rocks, and many other marvellous things.

When invited to a feast it behoves one to be cautious when the presents of food are placed before you, for maybe that food has been bewitched by some evilly disposed persou, and it is well to avert (*whiti*) the misfortune. You know, of course, that when the long heap of food is placed before guests the right-hand end as you face it is the *kauru* (head) and the other end the *take* (base). Before commencing to eat, your priest or man of knowledge will rise and, taking the basket of food from the extreme right, or *kauru*, he will place it on the extreme left, and shift the one on the left to the extreme right. This is a *whiti ora*, an averting of misfortune.

If you should happen to wound yourself—say, a cut by an

axe—you should instantly rub the axe on the wound and repeat the charm known as "*whai motu.*" If in walking you trip and hurt your foot, repeat the words "*Tina ora.*"

Mawake, of Kawerau, waxed old and died. He was buried at Waitaha-nui. After some time one Manaia was strolling past that spot and possessed himself of Mawake's jaw-bone, out of which he fashioned himself a fish-hook. One day Manaia and his people went out to sea to fish. As they lay fishing on the banks a fish leaped from the sea and dropped into the canoe of Manaia. That fish was an *aho*. Then the demons of the sea rose and utterly destroyed that people. Behold the power of the gods!

The custom of protecting crops or fish or forest products, or flax or ochre springs, &c., by means of a *rahui* was widespread in Maoriland—in fact, a universal custom. A post, termed *pou rahui*, would be set up and a bunch of fern or weeds tied thereto as a token of the *rahui*. Sometimes the head of a slain enemy was so used. When Tuhoe slaughtered Ngati-rangitihi at Rere-whakaitu they brought back to Rua-tahuna the heads of many chiefs. That of Tionga was taken to Tara-pounamu and there used to guard a famous bird-snaring tree.

The above post had no power in itself to punish poachers, but an object, such as a stone or branch, &c., was used as a *whatu* (kernel, an object to absorb the magic power), and was termed a "*kapu.*" Over this the incantations were repeated which had the power of destroying any person who interfered with the things protected by the *rahui*. The *kapu*, or *whatu*, was concealed near the *pou rahui*.

Waro rahui is another term used. "*Waro*" means a pit or chasm. A Maori would say, "A *waro* was dug that those who went to steal might descend thereby to death." It by no means follows that any pit was dug. The pit was the power of the spells of magic by which poachers and thieves were slain; that was the real pitfall. Such is one of the beauties of the Maori tongue. A person often means something totally different from what he says.

But, apart from the *rahui*, if it was found that poachers were snaring birds in a forest where they had no right, an offence known as "*kai haumi,*" search would be made for some of the feathers that may have fallen from the birds taken. These would be taken to the priest of magic, to act as an *ohonga*, or medium, between the incantations of the priest and the subjects; and trouble lay before the *kai haumi* gentry.

The causes of magic spells being employed were innumerable. Among others were quarrels concerning women, contentions between men as to items of ancient history, &c., jealousy, envy, and other causes too numerous to mention.

One of the earliest acts of magic (*makutu*) on record is the act of Maui when he caused Irawaru to assume the form of a dog. The cause of this act was that Whatu-nui, wife of Maui, had received attentions from Maui's elder brother, Maui-mua.

Kākā, a chief of Kahungunu Tribe, derived his name from the following circumstance: A leading chief of the tribe had been slain by a priestly magician named Moeroa, who, in conjunction with one Meke, of Te Wairoa, obtained some kākā birds and performed over them their magic rites, and then sent them to the above chief, who, eating of them, died the death. It was then that Kawatiri took the name of Kākā, in order to keep green the memory of that killing.

Another good way in which to dispose of enemies is to obtain one of the (cooking) stones from their ovens. You then have certain spells recited over this by a magician and return the stone to the oven. When next those people eat food that has been cooked in that oven—*he parekura!* there will be trouble.

Sometimes bitter wars arose in consequence of acts of *makutu*, or witchcraft. When Ngati-maru, of Hauraki, raided the eastern shores of the Bay of Plenty they took back home with them numbers of Ngai-tai and Ngati-ira. Some time after this Te Whata, son of Tu-te-rangi-anini, of Ngati-maru, died, and Ngai-tai were accused of having bewitched him and so caused his death. Ngai-tai denied the truth of this, but said that Te Aitanga-a-mahaki had done so. Whereupon an expedition of Ngati-maru sailed from Hauraki, under the chiefs Tu-te-rangi-anini, Te Popo, and Te Rohu, to square matters up. After their departure Ngati-ira and Ngai-tai evolved the idea that Hauraki was a good place to migrate from. They therefore left, and returned home by an inland route through Tuhoeland, eventually reaching Torere. The Ngati-maru party attacked and defeated Ngai-tai at Parepaopao. One account says that they went on and attacked Te Aitanga-a-mahaki, a Turanga tribe. Before returning home Ngati-maru also defeated Te Whaka-tohea, the fight being known as "Paenga-toitoi."

We have seen that when a person is taken sick he is taken to the waterside in order that the warlock may discover, by magic arts, the cause of the illness. Possibly you would like to know why a sick person is taken to the water. The reason is this: Wainui (the personification and origin of waters) is an ancestress of man, hence man is taken to her to be saved. And whether is his ailment a house, or a bed, or a sacred place, or a cacodemon, or a burial cave, there shall it be made clear—*i.e.*, violation of *tapu* places.

There is another way in which the arts of *makutu*, or

black magic, are used. When a man has served his time as a learner of the sacred history, religious rites (including magic), genealogies, mythology, &c., of his tribe, the time then comes when he must make some sacrifice in order to give power, force, *mana*, to the magic rites which he has learned during his novitiate, taught to him by the learned priests of the tribe. The teacher is not paid for his services by the pupil (*tauira*); the only payment made by the latter is the sacrifice above mentioned. The priest who taught him will tell the pupil that he must now, by his newly acquired magic powers, destroy one of his relatives—his wife, or father, or brother, &c. This is done, and the rites of the pupil will thus have due effect afterwards. Sometimes the pupil would first be given a stone, over which he would recite one of the numerous incantations which come under the generic term of "*hoa*." He would then cast the stone down on the ground, where it would be shattered. Should it not break, however, then his learning has been in vain, his *karakia*, or charms, will not be effective.

To prevent an enemy from passing up a river in canoes a pole is stuck in the river-bed, and a bunch of fern, &c., tied on to the part of the pole above water. After certain magic spells are recited over it any enemy passing up the river above the pole will be afflicted by divers disorders. Also, when a tribe wishes to prevent eels from going up a river beyond the limit of the tribal lands they set up a similar pole. A totara log in the river Rangi-taiki, at Nga-huinga, held this magic power until it was interfered with by the godless soldiers of Fort Galatea.

The evil eye (*titiro makutu*) is believed in by the Maori. When bathing one day at Rua-tahuna I was amused when a small child said to me, "*I titiro makutu a poti ki a koe, i a koe e kaukau ana*" (The cat was looking upon you with an evil eye whilst you were bathing). Fortunately I felt no evil effects from the evident hostility of her cat; possibly my immunity from trouble lay in my knowledge of the art of *mātāpuru*.

Fire-walking.

You have heard of fire-walking as practised by the Tahitians and Fijians, as also by Oriental peoples. Maori traditions assert that this rite was formerly practised by their priests in order to give force, power, to their incantations. The following is the only clear account of the rite that I have succeeded in collecting:—

"Te Rangi-kaku, of Nga-maihi, was in a bad way. Evidently the gods had deserted him, or he had not sufficient *mana* to call the demons of the deep to his rescue. It was in

this wise: Rangi had paddled merrily forth from Te Awa-a-te-atua to take the offspring of Tangaroa, who swarm in the Sea of Toi. A storm arose, the canoe was swamped, and Rangi, the fisherman, perished. His body drifted ashore at Wairakei, where it was found by the Tauranga people, who promptly cooked and ate it. Te Hahae, a noted warlock of Ngati-awa, heard of this occurrence, and inquired concerning the appearance of the drowned person. The answer was, 'He was a light-haired man, and had the *puhoro* pattern of tattooing on his left arm.' Te Hahae cried, 'Alas! He was my grandson, Te Rangi-kaku.' He at once despatched his daughter, Te Rere-wairua, to Puketapu (at Te Teko), to her brothers, Ouenuku, Rehe, and Tikitu, saying, 'Should your brothers consent to my proposition, let there be seventy separate *whawharua* (holes in which taro are planted), and only one taro in each, which must be cultivated so as to grow to a large size.' So she went, and arrived, and said, 'Te Rangi-kaku is dead and has been eaten. Te Hahae spoke in this manner: That taro be cultivated, that eels be caught (and cured).' These labours were commenced. The woman returned. Te Hahae asked of his daughter, 'How did your brothers receive the message which you took?' She replied, 'The taro are being cultivated.' Autumn arrived. The Tauranga people came to get the taro and eels. The dawn of the morrow came. The old warlock cried to Nga-maihi, 'Arise! Collect fuel and stones and covering (for the steam-ovens).' These things were collected. The old man said, 'The sacred oven, I will attend to that.' The people cooked their food, and Te Hahae prepared his sacred *umu* (oven). As he dug the hole he repeated a charm. As he placed the fuel therein he repeated a charm. As he placed the stones on the fuel he repeated a charm. When the stones were red with heat Te Hahae, clad merely in a girdle of green twigs and leaves, entered the oven and stood upon the red-hot stones thereof. There he stood and repeated his magic spells, yet was he not injured by heat, nor was his girdle affected in any way by flame or heat. Then he stepped out and proceeded to put the taro in the oven. Then he covered the taro with green branches and fern-fronds, and covered the oven with earth, repeating a charm as he performed each act. When the food was cooked he uncovered the oven and put the food in baskets, and placed these in a row, and presented the food to the people of Ngati-pukenga and Ngai-te-rangi. And each of these acts was accompanied by further spells of magic. Then those people thought as to what return they could make for this present of food. And it was said, 'We will go to the fishing-grounds.' Then those people paddled out upon the ocean. Te Hahae said to Nga-

maihi, 'Arise!' And Nga-maihi returned to their homes. They left the old man behind. He entered the water and by his magic power raised the wind (*uru-karaerae*) in furious violence. Thus appeared the wind, the lightning, the thunder, the hail. The sea was torn up. That storm caught the fishing-fleet anchored on the hapuku-grounds, and utterly destroyed it and the people thereof. So fell Tauranga; and the eating of the body of Te Rangi-kaku was avenged. Wrought by Te Hahae, the works of the wizards of old. Friend! This is the end."

Certain tribes are famed for their knowledge of witchcraft. Among these are the two divisions of Ngati-awa, and also the section of Ngati-kahungunu which lives in Te Wairoa district, on the East Coast. "*Wairoatapoko rau*" is a saying applied to that district. It is equivalent to "Wairoa, the engulfer of myriads," so many have been slain by the dark arts of those people. A sub-tribe of the Wairoa people, Ngati-hika by name, who lived at Te Mahia, are said to have made themselves so objectionable to their neighbours by means of their magic powers that the latter rose up and expelled them. They, or a portion of them, came to Tuhoeland, where they were given wives and settled down, thus becoming merged in the Tuhoe Tribe.

Only this morning I had a visit from three old women of Tuhoe. Passing by my camp, they called in to exchange greetings, and to weep over a photograph of one of their number who but recently drank of the waters of Tane-pi and lifted the world-old trail for Te Reinga. Anyhow, we got talking, and some questions of mine led to the following narrative from one of my visitors: When she was a young girl, eight years or so of age, she was *whakapakuwhatia*, or betrothed, by her tribe to a man of the Ngati-awa Tribe. Her aunt took her to that tribe, where they remained some time, but she, not liking the man, returned with her aunt to their own tribe. Some time after a party of Ngati-awa visited Ruatahuna, and one of their number abstracted a few threads of her clothing, which fragment was taken away to serve as an *ohonga*, or medium. Thus she and several of her relatives and friends were bewitched by Ngati-awa. The case called for instant action. One of the tribal *tohunga*, or wise men, who was *kauwaka*, or medium, of the *atua* (god, demon) known as Taimana, took all the patients to Matuahu *pa*, or fort, on the shores of Waikare-moana (where he made them live for several seasons). He said, "Let a cord and a mussel-shell be sought." These were found, and he proceeded to avert the magic of Ngati-awa and destroy the wizard. He bled each of the patients on the right shoulder and smeared the blood on the cord, which, together with the shell, he carried off to work

the spells of old therewith. The old lady did not know what the rest of the rite was. A shell was sometimes used by the wizard in such rites as the *rua-iti*, in order to "scoop" the spirits of the subject into the pit of death. The above people left Matuahu just before Witty's expedition against that *pa* in 1869.

There would appear to be a great similarity between different races in regard to their superstitions and magic rites. The finding of the *mātākai* in Abyssinia is interesting, but primitive races appear to evolve similar ideas all the world over. In this connection an article on "Chinese Magic" which lately appeared in the *Nouvelle Revue* is interesting.

Do not imagine that *makutu* is a thing of the past. Not so. It still obtains and is still dreaded. I heard but yesterday of a case wherein a half-breed of the descendants of Tionga is said to have been bewitched by Tuhoe, on account of his claiming their lands at Te Whaiti.

Tama-rae, of Ngati-awa, is said to have slain Tikitu by means of magic. So Tikitu's son promptly shot the wizard, and, being pursued by the Armed Constabulary, fled to Ruatahuna.

I am informed that native magicians have tried to destroy white men by means of magic, but somehow it does not succeed.

In the above pages are given but a portion of the numberless ways in which people were slain or affected by means of the black art. We will now give a few more items by means of which the spells of magic are averted and life saved. You are now aware of some of the innumerable dangers to which human life is exposed. Be equally diligent in learning how to save life.

MATAPURU.

I had been getting some information regarding Maori religious rites from an old man of Tuhoe. When the interview was over he said, "I must *mātāpuru*, that the information I have given you may not return (recoil) and kill me."

In the days of yore and the *mana Maori*, when the dread *atua* (demon) Tu-nui-a-te-ika (a meteor) was seen, the priests would at once proceed to *mātāpuru*—*i.e.*, to perform certain rites and recite divers incantations or invocations in order to ward off the *aitua*, or evil omen. The *mātāpuru* is an excellent plan by which to avert the effects of magic. Should I hear that a wizard is in the vicinity I would at once proceed to *mātāpuru*. I tie a number of pieces of green flax round my body, arms, and legs—say, three or four on each. This is termed a "*ruruku*," or binding-together of the body. I then

recite the *mātāpuru* incantation. The following is a specimen one; it is termed a "*momono*":—

Monokia te waha o te tipua
Monokia te waha o te tahito
Me puru to waha ki pari a nuku
Me puru to waha ki pari a rangi
E ki mai na koe, he tahito koe
He koeke, he kai-ure.

This *mātāpuru* is performed by travellers before entering a village where they imagine they may possibly be in danger of being bewitched.

The *karakia* known as "*titikura*" possesses great powers of healing, and is most useful in restoring to life those apparently dead.

Another good item is the *whakaeo*. This word means "to deprive of power." If you are attacked by a *taniwha*, or demon, you should at once pull a hair from your head and cast that hair towards your assailant, at the same time repeating the appropriate incantation, which is a variety of the *tuaimu*.

Here is another spell by which you may avert the evil omen of meeting or seeing the little green lizard:—

E tama!
E patu koe ki tua
E patu koe ki waho
E patu koe ki te hau e pa nei
E patu koe ki te papa e takoto nei
E patu koe ki te rangi nui e tu nei
Tau e riri ai, ko uta, ko tai
Ko rou ora
Ki te whai ao
Ki te ao marama.

The above is a *whakaeo*; it deprives the evil omen of power.

The following is said to be effective when you are in trouble with a *taniwha*, or water demon:—

Haere i tua, haere i waho
Haere i a moana nui, haere i a moana roa
I a moana te takiritia
Ki te whai ao, ki te ao marama.

But do not forget the hair.

The expression "*whakaeo*" is also applied to man; certain spells are recited or actions performed in order to deprive enemies of strength, vigour, energy, &c. Sometimes the medium of the tribal war-god will explain to the warriors that a certain act must be performed in order to *whakaeo* the enemy.

A man dies and is buried. Something causes his friends to think that he has been bewitched. The priestly worker of mysteries takes the matter in hand. He proceeds to the grave, carrying with him a stalk of the *rarauhe* fern. Over

this he repeats one of the innumerable spells which come under the generic term of "*hoa.*" The stick is left there. If it sinks and disappears in the earth it is known that the person died through the power of magic, and also that all persons implicated in that dark work will perish before long. If the stick does not so disappear, then the person was not bewitched.

The sterility of the women of Ngati-whare, of Te Whaiti, is said to be the result of magic spells of Ngati-awa Tribe.

The following is a *karakia* repeated in order to avert any misfortune, sickness, trouble, &c., which may be lurking about —*i.e.*, to preserve the people from all harm :—

Tua mai te whiwhia, tua mai te rawea—oi
Hao ki uta, hao ki te rangi nui e tu nei—oi
Haere ki waenga tapu
Tapu ihi, tapu rangi, toro i rangi
Tonoa mai te Pu, tonoa mai te More
More ki tua, More ki waho ra
Hukia mai te ihi
Hukia mai te hata papatea
Korihi te manu, korihi te po, te ata haea.
Huna mai te ruruku, kohera mai te ruruku
Uru ki tua, uru ki waho
Kei te awhenga, kei a tutakarewa.

I can accomplish the slaying of a person by going to the *tuahu*, or sacred place, and taking therefrom food which has been placed there for the gods, or some of the remains of meals partaken of by a first-born child, which remnants are also there deposited. I bring the same away and put it among the person's food that he may eat thereof. will perish.

When travelling it is always desirable to protect yourself against magic, and you can do this by means of the *whakau* rite. The people of the land may bewitch your food, or work some other evil art. You take a small portion of cooked food and repeat over it :—

To kai ihi, to kai ihi
To kai Rangi, to kai Papa
To kai awe, to kai karu
To kai ure pahore
Tiritiria makamaka
Kia kai mai te ati tipua
Kia kai mai te ati tawhito
E kai, e horo o tatau kaki
Kia kai nuku tatau
Kia kai rangi tatau
Kia kai mātāmua tatau.

Enough said. If any one has been bewitching you his magic spells will recoil upon his own head and slay him.

When in your sleep your *wairua* (spirit) goes forth from your body and wanders about, it is ever seeking to discover

any danger that may be threatening you, its physical basis. Should it discover that some person is bewitching you, it will at once return and you become aware of the fact. So soon as you awake go at once to the *tuahu*, or sacred place of the village, and stand there; but you must face in the direction of the place where the wizard lives, and then, stretching forth your hand, you repeat the charm beginning "*Whakataha ra koe e te anewa o te rangi e tu nei*" (Pass by thou whirlwind of the heavens, &c.). Having finished that, you then repeat the *tuaimu* charm, which has a most enervating and dangerous effect upon your enemy:—

Te imu kei te ruhi
Te imu k-i te ta, kei te anewa
To ringa i tu, to ringa i pe
Pepehi nuku, pepehi rangi
Rere taka o rangi ki waho
Kaki whatiia
Tuku tonu, heke tonu
Te ika ki te Po
He ika ka ripiripia
He ika ka toetoea
He ika ka haparangitia
Muimui te ngaro, tororo te iro
Mau ka oti atu ki te Po
Oti atu ki te Po wherikoriko.

The wind known as "Te Aputahi-a-pawa" is most boisterous. It begins with a gentle wind, known as "*hau mātāriki*," but after continuing for some time it becomes most fierce and is dangerous. Hasten at once to the water, to your mother Wai-nui, and stand therein. You have brought with you a piece of dead ember. You take this in your left hand and pass that hand under your thigh. Enough, the fierceness of that wind will at once abate.

Heoi! You have now seen how beset by dangers is man's path through life. You have also learned how to avoid such dangers. But the way is thick with snares and pitfalls; relax your vigilance for a few brief moments and the workers of evil shall fasten upon you. Above all, revere the laws of *tapu*. Keep green the memory of your ancestors, for of such are the gods of the Maori. They can save you from danger or send you down to Hades.

* * * * *

The long, weary fight against superstition which you have waged for many centuries, through sorrow and darkness and much suffering, it has just commenced here. Old Waihui, a frail survivor from the days of the levelled spear, when she heard of the marvels of the white man's hospital, said to me, "Oh! and if we had taken my son there he might still be with me."

And so the struggle goes on.

Art. VI.—*The Beginnings of Literature in New Zealand: Part II., the English Section—Newspapers.*

By Dr. T. M. Hocken, F.L.S.

[*Read before the Otago Institute, 9th July, 1901.*]

Last year I had the pleasure of placing before this Institute a sketch of the first, or Maori, section of New Zealand literature.* This had the interesting feature of being one introduced by ourselves and presented in their own language to a race whom we, as the superior intrusive people, are destined to supersede. On this occasion I propose to give some account of the purely English section of the subject as it struggled into life during the early period of this colony's existence.

The definitions of literature have been very various. Some would include under the term only the worthiest utterances or creations of the human mind made known to mankind through the art of writing. But for our purpose we must have something much more comprehensive, and must consider literature to mean the collective term for all writings. When our predecessors, the heroic colonisers, first came to these shores, and for many years after, life was beset with daily difficulty and danger, a condition which left little opportunity for cultivating the Muses; yet they brought with them provision for the production of a newspaper—that inseparable requirement of an Englishman—and it is in this adjunct that almost the first germs of New Zealand literature are contained. It cannot be pretended that much literary excellence is to be found in these early newspapers, but some account of them and of their writers—for editors in the present meaning of the word did not exist—must be interesting, and has an historical value.

On the 18th April, 1840, the first New Zealand paper saw the light. It was issued by Mr. Samuel Revans, who was thus the father of the Press in this colony. Its birthplace was in a raupo whare on the banks of the River Hutt, which falls into Port Nicholson. It was in this vicinity that the chief surveyor of the New Zealand Company was engaged in planting its earliest township, which was first called "Britannia," but afterwards by its present name of Wellington. Mr. Revans's previous history was sufficiently stirring, and marked him as one well suited to participate in the foundation of the young settlement. Born in 1808, and connected with the printing business, he emigrated to Canada in 1833, where he joined his friend Mr. H. S. Chapman, so well known to us as Mr. Jus-

* Trans. N.Z. Inst., xxxiii., p. 472.

tice Chapman. The two engaged in newspaper ventures, and brought out the first daily journal published in British North America—the *Montreal Daily Advertiser*. This was at a time when the country was seething in that prolonged political discontent which finally developed into insurrection, and even into rebellion—the so-called Canadian rebellion. Heart and soul the partners entered into the conflict, espousing, as we should say now, the side of right against might and oppression. Mr. Revans was denounced as a rebel, and a price was put upon his head; but he escaped pursuit, and then, meeting Edward Gibbon Wakefield and others interested in New Zealand colonisation, cast in his lot with them and their scheme. These gentlemen purchased a press and type for the benefit of the settlers who were about to sail, and intrusted the management and control to Mr. Revans. The first number of the paper was published in London just prior to the departure of these first settlers. There were two editions of it, one dated the 21st August and the other the 6th September, 1839. These were devoted to a history of the movement, and gave information to intending emigrants. A fortnight afterwards the first three vessels sailed—the "Aurora," "Oriental," and "Adelaide," in the latter of which was Mr. Revans and his freight. She took six months for her voyage; but there was no delay in the appearance of the second number, which, as I have said, was on the 18th April. It was of four pages, demy folio — that is, the size of the present *Otago Witness* or Christchurch *Press*, and also the size of all the earliest newspapers of the colony. Its original name was the "*New Zealand Gazette.*" To this was appended in the twentieth number the further title of "*and Britannia Spectator*," after the name given to the first town of the settlement. In November the name of the infant settlement of Britannia was altered to the more euphonious one of Wellington, and the paper assumed its final title of "*New Zealand Gazette and Wellington Spectator.*" It was issued weekly at a price of £2 per annum, or 1s. for single numbers. As a comparison the *Otago Daily Times* costs £1 6s. a year, for which we get a paper six times a week and at least five times larger. After eighteen months had elapsed—that is, in October, 1841—the *Gazette* was issued twice weekly, and so continued until a few months before its decease, when it reverted to the original weekly period. As we should expect from a knowledge of Mr. Revans's former experience, he conducted the paper with considerable business ability, if with little or no literary pretension. His politics were decidedly against the Government, not only, perhaps, because of old proclivities, but because of the constant antagonism between Auckland and Wellington. One was the seat of the Governor and British Government, the other was founded

by the New Zealand Company; their interests clashed, and bitter feeling and jealousy resulted. In its columns the company was warmly defended against its enemies, and the Wakefield system of colonisation had no more constant and able exponent. In these two features of its policy rested the germs of the paper's final decay and death. Its pages contain quite a mine of historical incident, gathered chiefly by scissors and paste from all parts of the young colony, and give another instance, if that were needed, of the necessity of preserving newspaper records containing, as they do, so many side lights of history and glimpses of a life so different from that of the present. From time to time the journals of exploration into the unknown country around are given at length, and occasionally there are articles on the natural history and productions of New Zealand, for amongst the early settlers were a few men of scientific mark. Dr. Frederick Knox, the well-known brother of the eminent Edinburgh anatomist, and Mr. Swainson, F.R.S., so celebrated as a naturalist, are examples.

Then came a time when the community ceased to thrive, misfortunes befell it, and discontent prevailed. From causes partly beyond its control the New Zealand Company showed diminished interest in its emigrants, and especially failed to place them in possession of the lands they supposed themselves to have purchased prior to leaving the Home-country, and it was then contended that the *Gazette* neither expressed the sentiments nor advocated the interests of the community. Such loss of confidence meant failure and invitation for a rival, and so on the 25th September, 1844, in its 363rd number, this interesting pioneer of New Zealand journalism closed its existence. I am inclined to think that Mr. Revans himself was not an inconsolable mourner. Long he had fought an uphill game, and frequently had deplored his diminished advertisements and his forgetful subscribers. After this he commenced sheep-farming in the Wairarapa in conjuction with his old friend Captain Smith, formerly the company's chief surveyor. But his life was destined yet to continue one of change and vicissitude. In 1851 he left for California, when the "diggings" were at their height, taking with him merchandise of timber and potatoes; but, like so many who abandon dissatisfied these happy shores, he speedily returned, never again to leave them. For a time he represented his district in the old Provincial Council of Wellington, but gradually he withdrew from public life, confining himself to farming pursuits, and died at Greytown on the 14th July, 1888, at the age of eighty years, unmarried. I can recall him as one of my first acquaintances in this country. Impelled by that special curiosity which

was so frequent amongst the earliest colonists, he came down to Dunedin to view the stirring life and change that had so suddenly transformed the quiet of this plodding settlement, and an attack of illness brought us into contact. He was of rough exterior, careless in dress, and wore a conspicuously large Panama hat. His eyes were dark, penetrating, and deeply set, surmounted by thick, bushy eyebrows. His manner was restless, and his speech, though intelligent, often coarse. Some of those adjectives will apply as qualities of his leaders.

The old press had its vicissitudes too. It was of the simple old type known amongst printers as the "Columbia," capable of printing two or three hundred copies per hour. From the *Gazette* office it passed into the service of one if not two subsequent newspaper offices in Wellington, and then, finding its way to Masterton, there printed the local journal until it and the whole plant were destroyed by a fire. An old pressman who had worked on it from the first then secured its remains, and these were exhibited as an interesting curiosity in the New Zealand Exhibition of 1889–90. I traced these six years ago, lying rusty and uncared-for on a small farm in the neighbourhood of Masterton, but failed in my efforts to secure them.

I have thus given at considerable, and perhaps tiresome, length an account of New Zealand's first newspaper, and specimens of it are here exhibited, as well as of those to which I shall later refer. The curious interest connected with it may be an excuse. Unfortunately, it is not possible within this evening's limit to treat the rest of my subject at similar length. The best mode of pursuing it will be to describe our newspaper literature rather according to locality than the sequence of date.

Continuing, then, with Wellington, the paper above referred to as a rival of the *Gazette*—though an unsuccessful one—was the *New Zealand Colonist and Port Nicholson Advertiser*, published twice weekly, at 6d. per copy, or 10s. quarterly, and at a charge of 3s. for an advertisement of six lines and under. Fifty of the aforesaid dissatisfied persons subscribed to its establishment, and Mr. (afterwards Sir) Richard Davies Hanson was its editor. This gentleman was one of the earliest Wellington settlers, and as a solicitor was there appointed Crown Prosecutor. In 1846 he left for Adelaide, and there became Chief Justice of South Australia, and also the first Chancellor of the University. He died in 1876. The first number of the paper appeared on the 2nd August, 1842, and the 105th and last precisely a year later. The increasing depression, together with the calamitous fire of November, 1842, which destroyed fifty-seven

houses on Lambton Quay, contributed to its early death. Its leaders were well written and free from the rough language so often a feature of the *Gazette*.

The existence of this paper is barely known; but the direct successor of the *Gazette* was the *New Zealand Spectator and Cook's Straits Guardian*, which was the outcome, as above indicated, of a sentiment that the pioneer had forfeited confidence and was no longer a representative mouthpiece. It was conducted by a committee of half a dozen of the principal gentlemen in the settlement, amongst whom were the well-known names of the Hon. Henry Petre, Mr. Clifford, and Mr. Lyon. Mr. Robert Stokes, formerly on the survey staff, was chosen editor; the issue was weekly, and the price, as with the *Gazette*, 1s. a copy and £2 per annum. The charge for advertisements was, however, soon reduced to 3d. a line. An active canvass resulted in 130 annual subscribers, and with the scanty income so derived, and further supplemented by advertisements, the *Spectator* commenced on the 12th October, 1844, what proved to be a difficult career. Barely had six months elapsed before a very scandalous advertisement appeared in its columns, followed in the ensuing week by an equally scandalous rejoinder. These were inserted by the printers without the knowledge of the committee, who, ashamed and indignant, removed at once their printing elsewhere. The offending printers were five in number, one of whom (Mr. Thomas Mackenzie) still survives, a very old and well-known citizen of Wellington, and all had been employed on the old *Gazette*. Without delay they issued a prospectus detailing and justifying the circumstances from their point of view, and accusing the committee of seeking to deprive them of their daily bread. And they did more than this, for on the 2nd April, 1845, they issued the first number of the *Wellington Independent*, for which they charged but 6d. a copy, considerably reduced the price of advertisements, and published twice a week.

This was carrying reprisals into the enemy's camp with a vengeance; and they were, moreover, well supported by a section of settlers of as good social standing as that of the committee, for, small though the community was, it yet possessed cliques. Mr. Mantell, for instance, son of the eminent geologist, lent his aid by carving several blocks to serve as divisional headings or woodcuts for the paper, which gave it a decidedly quaint and unusual aspect. These he carved from the native wood maire (*Olea*), which he found to be superior for the purpose to the usual boxwood. It must be confessed that the quantity of printing-ink requisite for these primitive illustrations too often communicated a smudgy appearance to the paper. Though the lofty *Spec-*

tator preserved a disdainful silence towards its humble rival, whose existence it deigned not to notice, it was preparing a most effectual means of extinguishing it. This was by purchasing the whole of the *Independent's* plant over the heads of the unsuspecting printers, who rented it and enjoyed a feeling of security in its unmarketable nature. But suddenly and secretly purchased it was, and on the 9th August, four months after starting their venture, the unlucky printers found themselves again adrift. They told the story to their subscribers in piteous terms whilst taking leave of them in the final issue. But their friends rallied round again and stoutly supported them. Fresh material was procured from Sydney, and in less than four months they jubilantly started anew. From this time onwards the two papers ran side by side as steady rivals for more than twenty years, until by the curious irony of fate the formerly poor persecuted *Independent* swallowed up or incorporated its more aristocratic opponent, which published its last number—the 2,088th—on the 5th August, 1865. Thus left the master of the situation, for a time at least, the *Independent* flourished nine years longer, issuing tri-weekly a six-page paper of large size at 3d. per copy, and then, on the 30th April, 1874, it in turn was incorporated with the *New Zealand Times*, which put forth its first number on the following day and has continued to the present time.

The pages of the two papers formed the arena of many a hard-fought battle in days when fighting was incessant and apparently an enjoyment, and when champions were doughty. In its earliest days the *Independent* boldly opposed the New Zealand Company and its land-purchasers; later it was a bitter opponent of Governor Grey and his methods, as well as an ardent supporter of Dr. Featherston and Mr. Fox, who were principal contributors to its columns.

An example of one of the many difficulties papers suffered under in those days—shortness of paper—is here exhibited. For many weeks the *Spectator* was obliged to appear on red blotting-paper, and uncommonly well that porous material appears to have taken the type. Sometimes they were compelled to print on paper of variable size, material, and colour, and specimens are extant printed in green and blue, such as might be used nowadays for handbills. In an early number of the *Nelson Examiner* the printer makes an earnest appeal to its readers for treacle. He says, "We beg to inform our readers that there is great probability of our press being rendered utterly useless for want of rollers. These are used for inking the formes, and an essential ingredient is treacle, and treacle we have been unable to procure for money. If any of our readers have any of this important article, and will spare

us some of it for love and money united, we shall be infinitely obliged. We are not *very* particular as to the price, but treacle we must have, or not only the *Examiner*, but bills, cheques, and the laws of the benefit society must remain for ever unbedevilled." It is satisfactory to know that a supply was forthcoming, inasmuch as the following number of the paper appeared on its due date. The old *Otago Witness* appealed at least once to its readers for paper of any kind, otherwise it would cease to appear; and cease to appear it did. This must surely have been at the time when the grocers requested their customers who required tea and sugar and suchlike incoherent articles to bring their own paper with them.

The Bay of Islands and the earliest Auckland newspapers come next in order, and they present quite a family resemblance in their poorness of paper and printing and meagre contents. The earliest of them—the *New Zealand Advertiser and Bay of Islands Gazette*—first appeared on the 15th June, 1840, just six months after the institution of British government in these islands, and two months after the birth of its contemporary, the *New Zealand Gazette*, at Wellington. It has thus the distinction of being the second paper issued in New Zealand. It was published at Kororareka, which adjoined the infant Township of Russell, where Governor Hobson had selected his seat, and it thus became the organ in which were published the first official notices and Proclamations. The Rev. B. Quaife was editor—a Congregational minister, and a gentleman who, in addition to his editorial functions, combined those of preacher and instructor of the young. Whilst the contents of his paper were, as might be expected, eminently respectable, they were undoubtedly poor. The burning question of the hour was the land-claims, which bore a somewhat different aspect from the same question amongst the settlers at Wellington. But in both instances the common ground of complaint was that the Government refused to recognise the validity of any purchase of land from the natives until official inquiry had been made and a Government grant issued—a tedious and expensive process indeed. Whilst this grievance was attacked in the distant south with the utmost vigour and acerbity, in the north it was approached with great circumspection, for there the Government was close by, and its iron hand was felt at once. The two classes of settlers represented, moreover, different types—one whose leaders were of a superior class, accustomed to all the advantages of responsible government and free institutions, which they had but just left, and who in emigrating recognised the true heroism of colonisation; the other who flocked down in numbers from New South Wales, ready to seize any

advantage in England's newly acquired territory, and glad, no doubt, to escape from the despotism of that Crown colony. It was thus that the land question proved the absorbing theme, to which all others were subsidiary, and that it, and the native connection with it, formed the almost sole politics of daily discussion. Not for long did, or could, Mr. Quaife avoid it, especially as other matters of perhaps more domestic concern, such as police, post-office, &c., were shamefully mismanaged. So, like the proverbial moth, he circled nearer and nearer to his doom, and after the issue of his twenty-seventh number, on the 10th December, which contained various moderate suggestions for reform, he was peremptorily directed to appear before Mr. Shortland, the Colonial Secretary, and threatened with all the pains and penalties of an old New South Wales Act regarding the printing and publishing of seditious newspapers. This meant, and proved to be, the extinction of his paper. To-day we might well ask, How could such things be? A meeting of the inhabitants was called, whereat there was much plain speaking, and it was resolved that a deputation should interview Governor Hobson on the matter and report. The late Sir F. Whitaker, then a young and inexperienced man, was one of the number. What the result was I could never learn, but unfavourable, no doubt, for the paper never reappeared.

Then followed, in foolscap folio, a rag indeed, called the "*New Zealand Government Gazette*," for it was necessary that the Government should have an organ for its notifications. From internal evidence I am inclined to think that the printer of the crushed *Advertiser* was employed, and that he was permitted to make the best private use of the paper after satisfying official requirements. Comical juxtapositions thus happened—private advertisements for lodgings, salt beef, and other merchandise displayed on the same page as those signed by His Excellency's command; and, in addition, there were a few items of news. It was published gratis, which, remembering the mode in which it rose from the ashes of its predecessor, seems enough. With the exception of the "*Gazette Extraordinary*" of the 30th December, 1840, which was really the first number, and printed at Paihia on the Church Mission press, it was issued at Kororareka from the 19th February, 1841, until the 15th July, nineteen numbers in all, and then it was superseded, at Auckland, on the 7th July, by the publication which has descended to us from that date, and is known to us all as the "*New Zealand Government Gazette.*"

It would appear that, though scotched, the Rev. B. Quaife was not killed, and had not forgiven the infliction of his old injuries. A company was soon projected, himself amongst the number, to protect the interests of the public from, as they

phrased it, the "continuous misrule and indifference of the Government," and their mouthpiece, the *Bay of Islands Observer*, accordingly made its first appearance on the 24th February, 1842—price 1s. a number, or 10s. quarterly, and 3s. 6d. for twelve lines of advertisement. Mr. Quaife, who was again editor, no longer approached abuses in a gentle, indirect manner, but handled them with so much candour and bluntness as to find himself and his company in danger of an action for libel, which was only averted by humble confession and apology. A little later—in October—and in its 39th number, it ceased to exist, deploring the little aid it had received from subscribers and the public.

More than a year now elapsed before the *Bay of Islands Advocate* published its first number, on the 4th November, 1843. Little need be said of it. It indulged in personalities, and was mourned by no one when it closed its short existence of three months in February, 1844. With it ends the list of Bay of Islands newspapers—four of them, with an average life of ten months each, surely an unusual record.

The Bay of Islands had always been the notable point of New Zealand. Its praises as a harbour and its beauty had been sung by Captain Cook, and after him it formed the rendezvous for whalers and the numerous shipping from Sydney, with which it was the proximate point. It was also the headquarters of the Church Mission, and thus it came to be selected as the seat of Government. But for this it was entirely unsuited, and after considerable search for a better site the British flag was finally unfurled on the banks of the Waitemata on the 19th September, 1840, at future Auckland. Then the glory of Kororareka began to depart, despite the hopes and efforts made to retain it, and the flocks that came down with Governor Hobson from New South Wales now took fresh wing to the newly selected capital, where the Governor began his permanent residence not earlier than March of 1841.

On the 10th July in the same year, at the usual old price of 1s. per copy, the first of Auckland's numerous newspapers appeared, the *New Zealand Herald and Auckland Gazette*, which has the distinction of being the third in order of New Zealand journals. Like its fellows in the farther north, its career was short and stormy, though at first seeming to possess the requisites of longer life and prosperity, and its promoters ought surely to have gained experience enough to avoid the rocks which had already caused so much disaster. Quite an extensive plant of printing material was brought down from Sydney, as well as a staff of pressmen for working it, amongst whom are names well known in early history—Mr. John Williamson, for instance, the first Superintendent of Auck-

land and editor of the *New-Zealander*, Mr. Wilson, of the *New Zealand Herald*, and others. The whole was the property of a company called the "Auckland Printing Company," under the management of another well-known name, J. C. Moore. The newspaper, however, with which we are concerned was a branch or part of the business, and its affairs were intrusted to four gentlemen, also well known — Major Richmond, Dr. Johnson, Mr. Montefiore, and Mr. William Mason, the latter of whom is well known to us as the first Mayor of Dunedin and member of the firm of Mason and Wales, architects. These gentlemen assisted the editor, Mr. Corbett, Mr. Montefiore, however, doing by far the most of the writing; but they knew nothing of newspapers, and failed to recognise how largely their success depended on advertisements. Moreover, the paper rather represented the views and desires of a Government clique than the needs of the public, and thus, receiving no sympathy, it soon showed signs of failure.

They then procured from Sydney the services of Dr. Martin, a medical man of considerable literary ability, forcible utterance, and powerful frame. Prior to colonisation he had been in New Zealand on a land-hunting quest, but, like so many others, had returned to New South Wales in high disgust when it became evident that the Government treated all so-called land-claims with a high hand and no favour. It will thus be conceived that, though the paper increased in literary ability, the chances of its survival were diminished. And so it speedily proved. Dr. Martin wrote with an iron pen, and laid about him with such flail-like agility that before two months had elapsed he was threatened with two or three actions for libel. Matters culminated when one day Mr. Fitzgerald, a Government official, Registrar of Lands and the Supreme Court, entered the office and seized from the printer, under threat of pains and penalties, some of the editors' manuscripts. Dr. Martin was furious, and, failing to secure the return of his property, challenged Mr. Fitzgerald to fight a duel. This the latter refused, and Dr. Martin thereupon posted him in various parts of the town as a blackguard and coward. The further details of this sanguinary business I do not here pursue, but before its termination it became a very pretty quarrel indeed, involving not only the officers of the garrison, but also such peaceable citizens as the late Dr. Shortland, so well known as the author of various works connected with old New Zealand history, and the present Dr. John Logan Campbell, now Mayor of Auckland.

The trustees of the paper grew penitent, finding too late that they had indeed replaced King Log by King Stork. Whilst they insisted that the paper should in the meantime be reduced to a mere advertisement sheet, supplemented with

newspaper clippings, their fighting editor insisted that the appearance of his articles was more than ever desirable. And so amidst this wild tumult Auckland's first paper ended in April, 1842, after ten months' existence. The whole printing plant of the company and the copyright of its defunct paper—*quoad valeat*—were sold by auction to the Government for £1,700, and remained under the management of the same printer, J. C. Moore.

Upon its ruins, and in a week's time, was erected the *Auckland Standard*, the second paper, and issued presumably in the interests of the Government, as might be expected. Yet, curious to say, it was not wholly so, for government in those days was not of the responsible type, and many of its supporters were half-hearted, swaying the balance according to personal interest. Besides, Governor Hobson was not entirely popular. Though strictly honourable and of high integrity, his manner was often overbearing and passionate, and had much of the quarter-deck character. The same may be said of his chief officials, Lieutenant Shortland and Mr. Coates.

The *Standard* was edited by Mr. William Swainson, who had recently arrived at Auckland under appointment as Attorney-General by the British Government. The prevailing fatality of early extinction befell it also, and on the 28th August, 1842, after but four months' struggle, the *Standard* also departed, mournfully deploring its own exit and the gloom which seemed gathering over the whole community.

Now appeared, on the 5th September, 1842, what surely was—or after the publication of its first few numbers was—the most extraordinary-looking paper ever printed. This was the *Auckland Times*, owned and edited by Mr. Henry Falwasser, formerly a storekeeper or merchant in Sydney, whose sister married the Rev. J. F. Churton, the first Auckland clergyman. At first it was printed by the accommodating Mr. John Moore on the type the Government had so recently purchased; but, whether any suspicion arose as to Mr. Falwasser's ability to pay for the printing or as to the doubtful odour of his articles, it is certain that Lieutenant Willoughby Shortland, then the Acting-Governor, speedily stepped in and stopped the paper somewhere about the tenth number. But Mr. Falwasser was a man of ingenuity and resource. From any quarter he gathered a miscellaneous assortment of old type, such as is mostly used for printing bill-heads and rough jobs, and, with the aid of a mangle and coarse paper, triumphantly produced these weekly specimens now regarded as such a curiosity. His original motto had been "*Veluti in speculum*"; now he changed it to "*Tempora mutantur—nos non mutamur in illis.*" His imprint was: "Auckland: Printed

(*in a mangle*) and published by Henry Falwasser, sole Editor and Proprietor." It is plain from the specimens here shown that the compression of the mangle varied much: sometimes it was so violent as to drive the ink through the paper, so that the letterpress can there be read by reversal, and sometimes it is so faint as to be barely legible. Words were printed with letters of various type, so that small capitals, italics, and old English met together in the same word, producing a most comical and mystifying result. If not a confusion of tongues, it was certainly a confusion of letters. Of course, the paper afforded great amusement, and doubtless had a good circulation, especially as it lashed out to the complete satisfaction of the public. Its comical characteristics and scanty pages no doubt protected it from the fiery persecution of those days, especially as the numbers were issued gratis until, as the editor assured his readers, proper type and paper could be procured from Sydney. But gradually its strange appearance improved with the occasional addition of a little new-found type, better paper, and better handling of the mangle, until, in its forty-second number, on the 13th April, 1843, it said farewell in quite a presentable form. On the 7th November it reappeared in legitimate form and in its new Sydney dress, once a week, and continued in its former hearty and independent style until the 17th January, 1846, when its 159th number was issued. A week later Henry Falwasser died, and with him ceased his journal, which, with all its vicissitudes, almost equalled in duration the united age of its predecessors.

The last of this class of old Auckland newspapers was the *Auckland Chronicle and New Zealand Colonist*, which put forth its first number on the 8th November, 1841, and shortly afterwards ceased, but when I have not been able to discover. Its second appearance, however, was on the 12th November, 1842, and in September, 1843, it commenced its second volume. It was printed by the usual John Moore in the interests of the Government, and was thus doubly obnoxious to the "mangle," which sneeringly spoke of it as "that administerial thing called 'the *Chronicle*'—bah!" In return the *Chronicle* dubbed its rival "The Old Lady of the Mangle," and advertised: "For sale, a mangle; apply to the proprietor of the *Auckland Times*." These little endearments were continuous, and it must be allowed that the "mangle" won the honours. Mr. John Kitchen—"which was where he came from," as Mr. Falwasser said—was editor of the *Chronicle*, and had previously been on the *United Service Gazette*. After leaving New Zealand he went to Hobart and Melbourne as a shorthand reporter. The final fate of this paper I have not been able to learn, but conclude that it must have closed its career early

in 1845. The *Southern Cross* in its first number was very bitter with it, and indulged on the occasion in one of those newspaper amenities which were then so common. One of its bitter references was: "For sale or hire, in about a fortnight, a defunct Government engine used for stifling the fire of the people; rather shaky, having lately stuck fast in the swamp of Queen Street. . . . Has been well greased lately, its head turning with marvellous facility in any direction. Apply at the *Chronicle* office."

I have now to say a few words regarding the *Southern Cross* and the *New-Zealander*, and with them can close the reference to the early Auckland papers. Both were of, or soon assumed, a very different and superior character from their predecessors, of whom so little can be said beyond a mere cataloguing, and both form a link connecting the old with the modern newspaper literature.

Dr. Martin, it will be remembered, terminated the existence of the old *Herald*, much against his will, in April, 1842, when the plant was sold to the Government. He was, as we have seen, highly indignant with the weak-kneed proprietors of that journal, and his first act was to bring an action against them for breach of his engagement as their editor. This he won, and £640 was awarded him. He further relieved his wounded feelings by writing a little pamphlet or letter, now extremely rare, addressed to Lord Stanley, then the Principal Secretary of State for the Colonies, entitled "New Zealand in 1842; or the Effects of a Bad Government on a Good Country." This pamphlet of thirty-two pages, 8vo, may, I think, be considered the first pamphlet printed in New Zealand. No longer restrained by interference with the freedom of the Press, or Newspaper Acts, or charge of libel, he here writes to his heart's content and in his most vigorous style. His next step was to receive type and press, and on the 22nd April, 1843, appeared the *Southern Cross, New Zealand Guardian, and Auckland, Thames, and Bay of Islands Advertiser*. The motto chosen was "*Luceo non Uro*"; but, as we can well fancy, it would have been better "*Luceo et Uro.*" The proprietor was Mr. William Brown, of the well-known firm of Brown and Campbell, a gentleman of wealth, attainments, and true citizenship. The old shanty in which it was printed was in Shortland Crescent, where I saw it about twelve years ago on the point of removal. Dr. Campbell gave me at the time much information regarding the history of the paper.

In 1844 Dr. Martin and Mr. Brown visited the Home-country—the former never to return—leaving the charge of the paper in Dr. Campbell's hands, Mr. Terry editing it, at a considerable loss, however. Dr. Campbell accordingly de-

cided to stop publication in April, 1845, and it was not resumed until July, 1847, upon Mr. Brown's return. In May, 1862, it became a daily paper, and shortly afterwards was sold by Mr. Brown to Mr. (afterwards Sir) Julius Vogel and his company, and was again sold in 1876 to Mr. Horton, and was soon afterwards amalgamated with the *New Zealand Herald*, belonging to Messrs. Wilson and Horton, who still own and conduct it, one of the leading and best journals in the colony.

During Mr. Brown's proprietorship the paper never paid. From first to last he lost £10,000 in it, and it was always making enemies; "nor was it conducted," says Dr. Campbell, "on commercial principles."

A final word may be said of Dr. Martin. He went Home a disappointed man, and there remained until he received the appointment of Stipendiary Magistrate in British Guiana. He died near Berbice on the 10th September, 1848.

The *New-Zealander* was fortunate in starting just after the temporary cessation of the *Southern Cross*, and on the 7th June, 1845. It belonged to Mr. Williamson, so well known in early New Zealand politics. He was soon joined in partnership by Mr. W. C. Wilson, and the two composed a firm long and well known as the printers of nearly every publication that issued from the Auckland Press. Amongst its editors and contributors were many men of note in New Zealand, such as Dr. Bennett, afterwards Registrar-General; Rev. T. S. Forsaith, of "white-shirt Ministry" fame; Dr. Giles, afterwards editor of the *Southern Monthly Magazine;* Mr. (now Sir John) Gorst, and many others.

Mr. Elliott tells me that Dr. Bennett, whilst of peculiar appearance, was of remarkable eloquence. He came down to Wellington, where he was almost unknown, about the time when the Duke of Edinburgh so narrowly escaped from the hands of the Sydney assassin, O'Farrell. A meeting of congratulation and sympathy was held on the occasion, at which the late Mr. FitzGerald made so eloquent a speech that other speakers were afraid to follow. In this difficulty one or two recognised the stranger's presence, and in a moment there was a cry of "Bennett! Bennett!" Dr. Bennett rose and delivered so brilliant a speech as quite to pale the fires of his predecessor. Such was his introduction to his new duties in Wellington.

The *New-Zealander* had the distinction of starting as the first morning penny paper on the 3rd April, 1865. A year later—in 1866—it closed publication.

An incident in the early life of the *New-Zealander* must not here be omitted. An article on Heke's war gave great offence to the naval men, who considered their honour con-

siderably tarnished thereby. Accordingly, armed with a hawser, a large number of sailors belonging to the warships in Auckland Harbour unexpectedly appeared at the door of the *New-Zealander* office in Shortland Crescent, through which they passed their rope to the back and then over the roof. A full retractation was demanded, failing which the building would be overturned. The beleaguered inmates, Messrs. Williamson and Wilson, yielded the point. But how, again the question may be asked, could such things be? What a liberty, or license, has been granted the Press during the last sixty years!

These two papers, comprising as they do more than a period of twenty years each, and dealing with the great transition period of New Zealand history, are laden with interest. Time forbids me just now to prolong this sketch of Auckland papers, and of even referring by name to several others which, though of less note, are yet old.

The next section in point of order is that of Nelson, like Wellington, a settlement of the New Zealand Company; like it, too, in that the first settlers came well provided with type and press, and, still further, with men of great literary ability. Hence it is that the *Nelson Examiner and New Zealand Chronicle* must be considered as by far the best and most literary of all the early journals, at least in its early existence. It was the property of Messrs. Charles and James Elliott, who had been previously engaged on the *Morning Chronicle*. The first editor was Mr. George Rycroft Richardson, a lawyer, who was afterwards killed at the Wairau massacre in June, 1843. The first number of the paper appeared on the 12th March, 1842, at the usual price of 1s., or £2 per annum.

Mr. Alfred Domett, that eminent New Zealand settler, succeeded to the editorship, and it is needless to say that in his hands the paper assumed a still higher character. The leaders can be read to-day with pleasure and profit. One is tempted to introduce extracts from some of them, but this is not the time or place to do so. Suffice it to say that they aimed higher than merely discussing the position and requirements of the settlers. Such important matters were never neglected, but they were discussed with a freedom from dogmatism and a respect for the opinions of others which conferred on them a power and force of conviction which belonged to no other paper in the colony. Always the readers were kept in touch with the important questions of politics and progress in the home which they had left. This was only what might be expected from one of Mr. Domett's ability. As we know, he was the friend of Browning, and the "Waring" of his well-known poem. Perhaps we know him better as the author of that New Zealand day-dream

"Ranolf and Amohia," and as one of our foremost early legislators and eminent colonists.

But Domett was not the only one whose name is inscribed on the roll of New Zealand history, and who contributed to make the *Examiner* what it was. The names of Dr. David Monro, William Fox, Dillon Bell, Richmond, Dr. Greenwood, and others must be added. And when these able men, as they were sure to do, went to other parts of the colony to discharge the high duties required from them by the advancement of New Zealand, then the paper gradually became an echo of its former self, and it expired in, I think, 1873.

I have by no means exhausted my subject, and must return to it. It was only when beginning to treat this second part that I realised its extent, and that it must be treated separately and alone from that higher class of literature which only developed later, and to which I hope yet to devote attention.

I will close my lecture with a few words of reference to New Plymouth, which, unlike its sister-settlements of Wellington and Nelson, brought with it no press provision. This was because its early settlers were not of the same superior and cultivated class. The bulk of them were small farmers and labourers from Devon and Cornwall, sober, industrious, and persevering men, than whom no part of New Zealand had better. Of course, such men as Thomas King, Charles Brown, and the Richmonds stood out in bright relief as men of culture, but they were few. Then came the Constitution in 1852; this made a newspaper necessary, and the requirement was satisfied by the *Taranaki Herald*, which first appeared on the 4th August, 1852, under the editorship of Mr. Wicksteed and Mr. Crompton for a short time, and then of Mr. Richard Pheney, a very clever and gifted man. Prior to its publication a board placed in a conspicuous position, and with any notices or notifications affixed in writing, did the duty of a newspaper. The *Herald* was until recently under the journalistic control of Mr. W. H. J. Seffern, who died last year.

ART. VII.—*On the Recent Statistics of Insanity, Cancer, and Phthisis in New Zealand.*

By H. W. SEGAR, M.A., Professor of Mathematics, University College, Auckland.

Plates II.–IV.

[*Read before the Auckland Institute, 2nd September, 1901.*]

I HAVE previously pointed out the rapid way in which the age-distribution of the population of New Zealand is changing.* Because of this rapidity of change in the population, numbers giving the proportion which those subject to any disease or infirmity bear to the whole population at different times are of little or no service for purposes of comparison unless the people of all ages are about equally subject to the complaint. If people of certain ages have more than the average liability to the disease, an increase in the proportion which the number of people of those ages bears to the whole population must tend to increase the proportion of the population subject to that particular affliction.

It follows that, for the proper investigation of the progress of any affection during any period, we must consider the extent to which each section of the people of about the same age has been affected by it during the period. This work I have carried out for insanity, cancer, and phthisis, three affections which, as they afflict severally a greater number of the human race than almost any other single disease, are likewise more the objects of popular interest than any others. With respect to each of them I have taken, for each sex and for various age-periods, the statistics for each year from 1879 to 1898, and have grouped them in five-year periods, each having a census year as the central year. I have then taken the averages for each period of five years and compared them with the populations of the same sex included in the various age-periods at the corresponding censuses. The results are, I think, of considerable interest, and will be described in the following sections.

There is no attempt made to institute comparisons with other countries. Such comparisons are of little value unless the statistics of each country are treated in some such way as that I have used in treating New Zealand; for the same reason that makes this method of treatment necessary in

* "The Population of New Zealand" (Trans. N.Z. Inst., vol. xxxiii., p. 453).

properly comparing the statistics of the same country for different years—that is, the difference in the age-distribution of the population—makes it necessary also in comparing the statistics of one country with those of another. Unfortunately, the necessary data for dealing in this manner with the statistics of any other country are not available in Auckland, and the work, therefore, cannot be attempted, though the results to which it would lead would be, I believe, of supreme interest.

Insanity.

The New Zealand Official Year-book tells us that the proportion which the inmates of the lunatic asylums of the colony, and those out on trial, bear to the whole population changed from 1 in every 383 of population in the year 1884 to 1 in every 288 in 1900, this being equivalent to an increase, relative to the whole population, of about 33 per cent. in sixteen years. The change was regular and continuous from year to year, and was not confined merely to the period just referred to.

On the strength of these and similar figures alarmist articles on the great increase of insanity frequently appear in our newspapers and magazines, and the greater strain of modern competition and the unhealthy conditions of city life are generally assigned as the chief causes. But others doubt the reality of so great an increase in insanity, and these suggest that the large number of good asylums, with the greater use made of those institutions, consequent upon the increased consideration shown for those suspected of insanity, may be responsible for much or all of the apparent increase, whilst the inclusion of a greater number of mental maladies under the head of "insanity" may still further tend to swell the numbers which so affright us. In any case, it appears generally accepted that, without these or similar explanations, the statistics of insanity indicate a continued increase in the modern man of liability to that mental disorder.

Now, I propose to show that the statistics of New Zealand do not indicate any real increase in liability to insanity, even if the numbers returned be taken as the proper measure of the amount of insanity in the colony. For this purpose I shall take the yearly admissions into the various lunatic asylums of the colony. As these will be classified according to age, it is necessary to leave out of consideration the small number of patients of age unknown, but this will not appreciably vitiate the results. The statistics must also be taken as given in the annual volumes of statistics issued by the Government—that is, with the idiotic included amongst the insane. The number

of the former class, however, bears but a comparatively small ratio to that of the latter.

Table I. represents the results obtained in the manner described in the introduction.

TABLE I.—AVERAGE YEARLY NUMBER OF PATIENTS RECEIVED INTO THE VARIOUS LUNATIC ASYLUMS IN THE COLONY PER 10,000 OF POPULATION OF EACH SEX OF VARIOUS AGE-PERIODS.

Ages.	Males.				Females.			
	1879–83.	1884–88.	1889–93.	1894–98.	1879–83.	1884–88.	1889–93.	1894–98.
0–5	0·0	0·0	0·0	0·0	0·0	0·1	0·0	0·0
5–10	0·5	0·5	0·2	0·3	0·4	0·2	0·4	0·3
10–15	1·3	0·9	0·9	0·7	0·9	0·4	0·7	0·6
15–25	7·1	5·5	4·9	6·3	6·9	5·7	4·1	5·1
25–35	16·8	13·2	13·3	12·9	13·9	13·2	10·4	10·0
35–45	18·9	17·7	15·2	16·7	18·6	12·6	13·7	15·7
45–55	17·5	15·0	14·3	15·2	14·4	13·3	15·9	18·2
55–65	17·7	14·8	13·1	16·2	11·7	10·8	9·6	13·6
65 and over	15·7	15·7	18·5	19·5	10·2	10·8	12·0	12·8

The results given in this table for the first and last of the four periods considered are illustrated graphically in Plate II.

Comparing generally the figures given in this table for the two sexes, it appears that there is little difference for the sexes for ages up to 55 years, but after that the tendency to insanity is markedly greater in males than in females.

With respect to the males, it may further be noted that there was actually, during the whole period, a diminution in the number of patients supplied for each 10,000 of population for all ages up to 65; only for ages 65 and over is there an increase, and this is from 15·7 to 19·5. Further, during the years 1879–83 there were 1,207 male patients of known age received into the various asylums, and during the years 1894–98 the number was 1,508; but, if the populations of the various age-periods had supplied patients in the latter period in the same proportion to their numbers as in the former, the number of admissions from 1894 to 1898 would have been as many as 1,771. Thus the statistics, if they fairly correctly represent the amount of insanity, indicate an undoubted substantial diminution in the chance of insanity for the average male.

In the case of females there was, during the period considered, a diminution in the number of fresh cases of insanity relative to the population for all ages up to 45; in the three

age-periods above this age, however, there was an increase. But the earlier age-periods supply so few patients that it is not apparent from these facts alone whether on the whole there was a true increase or decrease of insanity amongst females. We find, however, that during the years 1879–83 there were 739 female patients of known age received into the various asylums, and during the years 1894–98 the number was 1,095; but, if the populations of the various age-periods had supplied patients in the latter period in the same proportion to their numbers as in the former period, the number of admissions from 1894 to 1898 would have been as many as 1,230. Thus we get with respect to females a result, as far as the figures are concerned, like to that we formerly obtained for males—namely, an undoubted falling-off in liability to insanity. The same result thus follows for the population as a whole.

To what degree of correctness the statistics represent the actual state of things is another question, into which I do not propose to enter; but the concern about the increase of insanity, which inspires so many articles, is founded on the figures as roughly put in statistical works, and I have shown that these figures, properly interpreted, afford no justification whatever for the inference usually deduced from them, but rather indicate a strong tendency in the direction of growing sanity.

If the reasons usually assigned to explain the commonly supposed increase in the tendency to insanity have really any force, if many are now classed as insane that would not have been so classed some years ago, and if many are now placed in institutions for the care of the insane that some time since would not have been so provided for, then there must indeed have been in recent years a very real and very marked diminution in the liability of the New-Zealander to insanity, in spite of modern competition and the disadvantages of city life. In fact, explanations are now wanted to account for statistics indicating a falling-off, and not a growth, in the tendency of the race to insanity.

Thus far we have considered only the yearly contribution of the colony to the total insane population, and it may not be yet quite clear how it is that the total insane population is increasing so much more rapidly than the population as a whole. The explanation lies in the great changes taking place in the age-distribution of the people, which has been fully explained in the paper already referred to.

Table I. shows that there is no great liability to insanity till about the age of 25, whilst after that age there is no very great change in this liability; indeed, the number of insane

persons under the age of 15 might, for most purposes, be entirely neglected. Now, whereas the total population of the colony increased between 1881 and 1896 by 43·8 per cent., the population in some of the later age-periods considered as much as trebled. Further, the number of people that become insane in any age-period during any year, as represented in Table I., does not represent the number actually insane in that age-period, for that number includes the survivors of all those belonging to that age-period who became insane in previous years and failed to recover. Thus the number of insane in any section of the people is cumulative relatively to the population, and the number of insane per 10,000 of the population must increase rapidly in the age-periods of maturity as we rise from one age-period to a higher one. This is quite distinct from the liability of sane persons at those ages to develope insanity, and, with the rapidly increasing proportion of the whole population included in the later age-periods, completely explains the continually growing proportion of the population that are afflicted with insanity. Considerations brought forward in the paper already referred to, leading us to expect a continued rapid increase for many years to come in the proportion that the old bear to the whole population, also lead us to expect a similar increase with respect to the insane, and this without the aid of any increased liability of the race to insanity, and possibly even in spite of a falling-off in such liability.

CANCER.

The statistics of cancer as commonly presented make it appear that that relentless disease is increasing its ravages at a rate that is somewhat horrifying. In the year 1879 there were 118 deaths from cancer, forming 2·11 of the whole number of deaths. and being at the rate of 2·63 deaths per 10,000 of population, whilst in 1898 the number of deaths from cancer was 471, forming 6·50 of the whole number of deaths, and being at the rate of 6·40 deaths per 10,000 of population. The number of deaths from cancer thus increased some two and a half times relatively to the population during the period of twenty years under consideration. We shall apply, however, the same kind of analysis as that just used for the case of insanity; and the results, though not yielding a conclusion just the reverse of the popular notion, as in the case of insanity, will still be found to considerably modify the estimate generally formed of the progress of this disease.

Table II. presents the results obtained in the manner already described.

TABLE II.—AVERAGE YEARLY NUMBER OF DEATHS FROM CANCER PER 10,000 OF POPULATION OF EACH SEX OF VARIOUS AGE-PERIODS.

Ages.	Males.				Females.			
	1879–83.	1884–88.	1889–93.	1894–98.	1879–83.	1884–88.	1889–93.	1894–98.
0–5	0·2	0·2	0·4	0·2	0·3	0·0	0·2	0·1
5–10	0·0	0·2	0·1	0·1	0·1	0·0	0·1	0·2
10–15	0·0	0·1	0·1	0·1	0·1	0·1	0·1	0·1
15–20	0·1	0·3	0·3	0·2	0·0	0 1	0·0	0·1
20–25	0 6	0·3	0·6	0·4	0·1	0·1	0·3	0·3
25–30	0·4	0·9	0·6	0·3	0·9	0·6	0·5	0·8
30–35	1·1	0·9	0 7	1·0	2·1	2·6	2 2	2·4
35–40	1·5	1·5	2 5	2·3	4·2	4·3	5·3	4·5
40–45	4·2	4·9	4·3	5·5	8·9	9·7	10·1	10·2
45–50	7·2	9·2	8·6	9·9	14·9	15·3	12·5	20·3
50–55	11·9	13·7	16·3	17·4	20·8	24·3	22·6	22·0
55–60	17·5	22·3	24·1	29·0	29·7	33 6	34·1	35·4
60–65	20·1	31·7	39·5	43·4	27·7	34·0	36·7	40·1
65–70	34·2	42·8	52·8	47·7	45·8	36·7	60·1	47·1
70–75	23·8	44·5	58·4	64·0	37·3	51 7	39·4	53 5
75–80	48·2	46·8	58·8	77·0	58·4	47·4	55·6	64·8
80 and over	31·1	38·1	44·6	42·8	38·2	51·3	31·8	36·4

The results given in this table for ages 30 and over, and for the first and last of the four periods considered, are illustrated graphically in Plate III. For ages under 30 the numbers of cases are too small to give fair averages.

The figures of this table show that from 30 to 60 years of age females are more subject to the disease than males; indeed, between the ages of 30 and 50 the chance of dying of cancer is about double in the case of the female of what it is in the male, but after the age of 60 there is an opposite tendency, though one not so marked.

In this table, it may be further noted, the results for ages up to 30 years indicate how small is the chance of death from cancer at those ages compared with subsequent ages, but are otherwise of little service, the number of deaths being too small to give a fair average.

From the age of 40 in males and 35 in females the number of deaths from cancer is considerable for each age-period, and is generally the greater the greater the age, with the exception that, after the age 80 years, there appears to be a falling-off in liability to death from this complaint.

Thus cancer is eminently a disease associated with degeneration, and most commonly afflicts the aged. Consequently much of what has been said with respect to insanity will apply to cancer, and we are thus prepared to find that much of the apparent increase in cancer is due really to a relative

increase in that portion of the population most liable to suffer from its inroads—namely, the aged. But we are not so fortunate in this case as to find the whole increase thus explained, with a credit balance on the other side. There is undeniably an increase in cancer, as represented by statistics. This is generally, however, not nearly so great as would appear at first from the simple statements with the quotation of which this section opened. The increase in cancer, as properly represented by statistics, is thus more capable of being explained away by the reasons that have been given from time to time for its apparent increase in New Zealand and elsewhere. The Registrar-General of England, for instance, expressed the opinion that part of the increase was due to improved diagnosis and more careful statement of cause, in support of which opinion he pointed out the greater proportionate apparent increase in the deaths of males from cancer, a fact plainly apparent for the case of New Zealand in Table II. This disproportionate increase for the two sexes he explained as being due to the fact that "the cancerous affections of males are in much larger proportion internal or inaccessible than those of females, and consequently are more difficult of recognition, so that any improvement in medical diagnosis would add more to the male than to the female figures." Whether all or how much of the apparent increase in liability to deaths from cancer can be explained by these suggestions of the Registrar-General of England is a matter, however, on which I cannot venture to express an opinion.

PHTHISIS.

Phthisis, commonly known simply as consumption, has of late excited none of that alarmed interest that has centred round insanity and cancer; it has supplied no startling figures appearing to indicate irresistible conquest. At the beginning of the period we are considering, in the year 1879, the number of deaths from phthisis was 399, or 8·90 per 10,000 of population, while in 1898 the number of deaths was 597, but only 8·11 per 10,000 of population. These figures in themselves should not, however, be taken to indicate a real decrease in liability to death from phthisis. As far as these figures go, the relatively smaller number of deaths from phthisis might be due to the section of the population of those ages most liable to death from phthisis forming more recently a smaller proportion of the whole population. To draw proper conclusions we must proceed to a more detailed analysis.

Table III. exhibits the result of applying the same method as that already applied to the other two diseases.

TABLE III.—AVERAGE YEARLY NUMBER OF DEATHS FROM PHTHISIS PER 10,000 OF POPULATION OF EACH SEX OF VARIOUS AGE-PERIODS.

Ages.	Males.				Females.			
	1879–83.	1884–88.	1889–93.	1894–98.	1879–83.	1884–88.	1889–93.	1894–98.
0–5	2·0	1·3	0·6	0·8	2·2	1·6	1·5	0·8
5–10	0·5	0·5	0·3	0·3	1·2	1·3	0·7	0·3
10–15	0·9	0·9	1·1	1·0	2·9	2·6	1·8	1·8
15–20	7·2	7·0	5·8	4·6	10·5	9·7	10·7	11·4
20–25	15·6	17·3	14·2	15·0	16·3	17·0	16·6	14·5
25–30	16·6	19·1	18·1	14·3	21·8	15·2	16·0	14·5
30–35	18·5	16·9	14·0	13·4	18·2	19·1	15·3	13·5
35–40	17·7	15·6	15·3	14·0	15·6	15·4	15·4	14·3
40–45	14·9	14·4	13·0	11·5	14·4	10·8	10·1	13·3
45–50	16·2	15·6	14·2	11·6	12·5	10·1	11·0	9·4
50–55	13·6	17·2	14·3	13·3	9·6	9·7	12·3	7·3
55–60	23·3	15·9	16·1	13·6	14·8	9·5	10·7	8·8
60–65	14·3	15·3	15·3	17·7	7·1	8·2	8·1	8·3
65–70	16·0	13·8	15·9	17·6	5·3	9·4	6·2	6·9
70–75	8·5	7·6	13·6	11·2	2·2	4·9	3·2	1·8
75–80	10·3	7·0	5·0	14·1	0·0	3·0	8·5	5·8
80 and over	0·0	7·6	5·6	8·2	7·6	0·0	0·0	4·6

The results given in this table for ages up to 65, and for the first and last of the four periods considered, are illustrated graphically in Plate IV. For ages over 65 the numbers of cases are too small to give fair averages.

This table shows that during the ages from 10 to 20 females are much more liable to death from phthisis than males, but from 45 onwards the position is more than reversed.

Phthisis is often regarded as a disease of youth, but this table shows that though this is the case to a considerable extent for females, yet for males from the age of 20 years, when the chance of death from phthisis first becomes considerable, it remains comparatively constant up to the age of 70 years, when a decrease sets in.

Leaving out of further consideration the ages 65 and over, because of the comparatively small number of cases they supply, we see that for other ages the number of deaths per 10,000 of population fell off during the period under consideration for the great majority of age-periods. In fact, in the case of males the only age-period showing an appreciable increase was that of 60–65, and in the case of females the only age-periods showing an increase were those of 15–20 and 60–65, and the increases in both these cases were comparatively slight.

Thus, on the whole, there was during the period a very gratifying falling-off in the ravages made by this insidious disease.

CONCLUSION.

It is somewhat beyond my province to attempt to comment on the figures I have brought forward from a point of view that should be left to the medical expert. My only object has been to present the statistics of the three diseases in the manner in which I think they should be presented, and one that leads to the possibility of sound and not fallacious inference. My only regret is that I have not been able, from lack of material, to extend the investigation to other populations than that of our own colony. If others with the available material to hand will take up the work, I am convinced they will succeed in obtaining results of supreme interest to all who are interested in statistics so closely concerned with the health and welfare of the race.

ART. VIII.—*On some Relics of the Moriori Race.*

By ARTHUR DENDY, D.Sc., F.L.S., Professor of Biology in the Canterbury College, University of New Zealand.

[*Read before the Philosophical Institute of Canterbury, 2nd October, 1901.*]

Plates V. and VI.

THE Moriori race is already on the verge of extinction, and at the time of my visit to Chatham Island, in January, 1901, there were only about a dozen pure-blooded individuals remaining, some of whom were of great age, while the youngest was a lad of about sixteen. Under these circumstances it must be considered as extremely fortunate that any reliable record of this interesting people has been preserved. That such is the case is due chiefly to the energy and enthusiasm of Mr. Alexander Shand, who for more than thirty years has lived amongst the Morioris, and has made a special study not only of that race, but likewise of their Maori conquerors. Mr. Shand, whose acquaintance I first had the pleasure of making at his home on the island, has published a series of very valuable papers on the subject in the *Journal of the Polynesian Society*, from which, as well as from my personal intercourse with the author, much of my information has been derived.

It appears from their language, customs, and traditions, as well as from their physical characteristics, that the Morioris were closely related to the New Zealand Maoris, from whom, indeed, none but an expert could distinguish them, though Mr. Shand considers that they are, if anything, a shade darker and perhaps even more of a Jewish cast. Mr. Travers, in his extremely interesting paper on the "Traditions and Customs of the Morioris,"* gives good reasons for believing that they are of mixed origin.

The discovery of the island, known to the Morioris themselves as Rĕkŏhu, in 1790 by the brig "Chatham" may be said to have sealed the fate of these unfortunate people, though it is doubtful whether any serious injury ensued until the advent of the whaling and sealing vessels in 1828. These vessels took many undesirable visitors to the island, and probably introduced a disease which soon played havoc with the native race. On board some of these vessels were Maoris from New Zealand, who, on their return, painted such a glowing picture of the land of plenty that a large number of their fellow-countrymen determined to emigrate to Chatham Island—or, as they called it, Wharekauri—*en masse*. In order to effect this purpose they took possession of the brig "Rodney" at Port Nicholson about the beginning of November, 1835, seizing the crew and by fair means or foul compelling the captain to take them to the island, whither, in two trips, about nine hundred Maoris were transported and let loose upon the unfortunate inhabitants, already decimated by some virulent disease.

Those who are fond of extolling the virtues of the Maori race would do well to study the history of their occupation of Chatham Island. At the time of the invasion the Morioris are said to have numbered some two thousand, and had they attacked the new-comers on their first arrival, when they were too weak from the effects of their voyage to resist, they might have exterminated them with little trouble. Unfortunately for themselves, however, the Morioris had lost the noble art of self-defence; killing was forbidden by their laws, and, like the wingless birds of New Zealand, they fell an easy prey to the first enemy. The invaders proceeded to parcel out the country amongst themselves, claiming not only the land but also the inhabitants thereof, who were speedily reduced to the condition of slaves and put to hard labour for their brutal masters. Mr. Shand tells us how "Te Wharekura, of Te Raki, with his hapu, killed and roasted fifty Morioris in one oven—it might have been more than one—for no reason whatever that could be assigned"; while at Waitangi one Tikaokao

* Trans. N.Z. Inst., vol. ix., p. 15.

and others massacred men, women, and children of the conquered race, and laid them out on the sandy beach touching one another, some of the women being left to die with stakes thrust into them.

It may be of interest to compare with this account the brief remarks on the Moriori race made by the Bishop of New Zealand, who visited Chatham Island in 1848: "In appearance they are not very different from the New-Zealanders, and their language at the time of the invasion (about ten years ago) was perfectly intelligible to the Ngatiawa Tribe, who usurped their territory. Their name, as spoken by themselves, is 'tangata Maoriori,' differing from the name of the New Zealand people only in the reduplication of the last syllables; but the conquerors have given them the title of 'Paraiwhara,' the meaning of which I could not ascertain. Their number at the time of my visit, by a careful census which I took of the names of men, women, and children, was 268; but the very small number of children and the unmarried state in which they seemed for the most part to be living would lead me to fear that they were rapidly decreasing. The relation in which they stand to the New-Zealanders is not satisfactory. They have been reduced to the condition of serfs, and are obliged to obey the orders of every little child of the invading race. The common expression of 'Ngare Paraiwhara' (Send a Paraiwhara) shows that a 'fagging' system has been established, more injurious, perhaps, to the masters than to the servants, as there is no appearance of harshness or severity, but a great decrease of personal activity in the dominant race. A long residence on the island would be necessary to do away entirely with this evil; but I did what I could in a short visit by paying personal attention to the poor Paraiwhara, and explaining how they were descended from the elder branch of the family of Noah, by which they obtained the name of the 'tuakana o te Pihopa' (the elder brother of the Bishop). They are a cheerful and willing people, and, like many persons in a subordinate station, more obliging than their masters. Amusing stories are told of the first invasion of the island, at which time the chief food of the Paraiwhara was the supply of eels from the numerous lakes which cover perhaps half the surface. When potatoes were first given to them they impaled them upon skewers, after the manner of cooking eels, and sat watching till the oil should drop from them. Their canoes are ingeniously made of small sticks carefully tied together, as there is no wood on the island suitable for a solid canoe."*

* "Church in the Colonies (No. xx., New Zealand, part v.): A Journal of the Bishop's Visitation Tour through his Diocese, including a

Considering how comparatively soon his visit followed upon the atrocities recorded by Mr. Shand, it is difficult to understand how the good Bishop could have been kept so much in the dark as to the true history of the Maori usurpation as his remarks would lead one to suppose. It is not difficult to believe that whoever invented the title "elder brother of the Bishop" for the unfortunate Moriori was gifted with a certain sense of humour, but the "amusing stories" of the first invasion were probably very carefully selected before they were allowed to come to the ears of the distinguished visitor.

With the advent of European settlers the condition of the Morioris was doubtless greatly improved. As, however, the Maori occupation of the island took place prior to the Treaty of Waitangi, their ownership of the land by right of conquest has been admitted, with the exception of 2,000 acres, which they have been obliged to set apart as a reserve for their former slaves, of whom the remnant appear now to be very well treated, and to live on terms of equality with both Maoris and Europeans. The younger ones, at any rate, dress like Europeans and follow the same occupations—in fact, they are so completely "civilised" as to be no longer of much scientific interest.

The extent of the Moriori population in former years is still attested by the immense quantity of human remains with which the shores of the island are littered, and by the abundant evidence of native handiwork. At intervals along the low sandhills which fringe the greater part of the shore old burying-places and huge shell-mounds or "kitchen-middens" are met with. It was the custom of the race to bury some, at any rate, of their dead in the sand by the sea-shore, in a sitting posture, facing the west, with the elbows down and the knees up. In many places the remains have been exposed by the wind, and the shore is strewn with skulls and bones in various stages of dismemberment. Owing doubtless to the ease with which graves are scooped out in the loose sand, the Maoris chose (at any rate, at first) similar situations on the island for their cemeteries, so that it is now by no means easy to say whether any particular skull or other bone picked up on the shore belonged to one of the conquered or one of the conquering race. The only safe plan for those who wish to obtain specimens for scientific investigation is to dig out the entire skeleton, when the sitting posture may be regarded as sufficient proof of Moriori origin, for the Maoris appear to have buried their dead in a horizontal position.

Visit to the Chatham Islands in the Year 1848." London. Printed for the Society for the Propagation of the Gospel, and sold by the Society for Promoting Christian Knowledge. 1851.

When out riding on the shore close to the chief centre of population (Waitangi) I came upon a place where the sand-cliff was crumbling away, and old coffins were tumbling out in fragments and discharging their contents in ghastly medley—in one lay the remains of a man, with an old toothbrush, numerous buttons, and clay pipes close by; in another the remains of a child with the bones of the feet still in the boots, for the corpses appear to have been buried in their clothes, together with their personal effects. On at least one occasion the Maoris are said to have removed the bones from one of these burial-places to a more suitable locality.

Although human remains are left to be kicked about on the beach by the hoofs of the horses in the most promiscuous manner, yet the Maoris and half-castes have a strong objection to any one interfering with the bones. One of them tried to persuade me that any such interference was punishable by fine, though I believe there is no power on the island authorised to inflict such a penalty. The Maoris, however, still own much of the land, and, with the half-castes, are about equal in number to the Europeans, with whom they are quite on terms of equality. Hence they can make things uncomfortable in many ways if they choose to do so, and it is desirable for the sake of peace to observe their prejudices as far as possible, though it certainly seems a little strange, in view of their treatment of the Morioris, that they should feel so strongly with regard to the removal of the bones of their victims. Possibly there is some superstitious feeling about it, perhaps some lingering idea of *tapu*, or perhaps they fear lest the remains of their own people might also be disturbed. I had the pleasure of being hospitably entertained by one half-caste who had fenced in an old Moriori burying-place on his own property in order to keep the stock away from it, with the unexpected and very pleasing result that the great forget-me-not (*Myosotidium nobile*), the so-called "Chatham Island lily," with its huge rhubarb-like leaves and bunches of blue flowers, elsewhere almost exterminated by the sheep, has begun to spread again vigorously in this locality.

At Wharekauri, Mr. Chudleigh's estate in the northern part of the island, I saw many bones lying beneath the trees in a dense thicket near the shore, and was informed that the Morioris sometimes tied their dead to trees in erect postures with a stick in hand pointing upwards to represent a pigeon-spear, the bodies being tied with the stems of that curious climbing plant, the supplejack of the settlers (*Rhipogonum scandens*). Mr. Gilbert Mair, in a paper read before the Wellington Philosophical Society in 1870,* also refers to this

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* Trans. N.Z. Inst., vol. iii., 1870, p. 311.

mode of burial. He says, "In some instances the corpses were placed upright between young trees and then firmly bound round with vines, and in course of time they became embedded in the wood itself. Sometimes they were placed in hollow trees. Several skeletons have lately been discovered by Europeans in trees which they were cutting up for fire-wood, &c. In other cases the corpses were placed on small rafts constructed of the dry flower-stems of the flax. Water, food, fishing-lines, &c., were then placed by them, and they were set adrift and carried out to sea by the land breeze. Not long ago an American whaler discovered one of these rafts with a corpse seated in the stern many miles from land. Not knowing that it had been set adrift purposely, the captain had a rope attached to it and towed it into Whangaroa Harbour, much to the annoyance of the natives." Mr. Mair makes no mention of burial as a mode of disposing of the dead.

In considering the funeral customs of the Morioris we must certainly take into account the extraordinary tree-carvings so abundant in some parts of the island. It is remarkable how little attention these carvings have hitherto excited. A good painting of some of them, by Miss Stoddart, may, however, be seen in the Canterbury Museum, which has also, since my visit to the island, acquired three actual specimens. Mr. Travers also, in his extremely interesting paper on the "Traditions and Customs of the Morioris,"* gives illustrations of some of these figures, which he explains as follows: "Their quarrels appear to have arisen chiefly out of conflicting claims to the possession of valuable karaka-trees, the fruit of which was a staple and much-liked article of food, and my son informs me that nearly all the older karaka-trees on the island are marked with devices indicating their special ownership—a fact of very great interest. He made drawings of many of these figures, which are very rude, but were evidently sufficient for the purposes of the owners."

I myself took the opportunity when on the island of making a number of sketches of these tree-carvings, which are reproduced in the accompanying plate (Plate V., figs. 1–4). They are commonly about 3 ft. in total height, and those which I saw, as well as those in the Canterbury Museum, those drawn by Miss Stoddart, and some of those figured by Mr. Travers, are evidently intended to represent the human skeleton in the sitting attitude. The elbows are represented pointing downwards and the knees upwards, and some of them have unmistakable ribs (figs. 3, 4). The head is commonly represented with a curious cleft on top (figs. 1–3),

* Trans. N.Z. Inst., vol. ix., p. 25.

so that the outline becomes somewhat heart-shaped. In one case (fig. 4) the head was replaced by what appears to be the figure of a hand with an eye on each side of it. This had possibly some symbolical significance. The hands and feet show a varying number of digits up to five, and the backbone is represented by a straight line.

The figures in question appear always to have been carved in the bark of the kopi-tree or karaka (*Corynocarpus lævigata*), whose large succulent drupes formed one of the principal articles of food amongst the Moriori, and whose smooth bark is particularly suited for the purpose. The outlines are generally incised, but in two of the specimens in the Canterbury Museum they are left in relief. These figures may, as indicated by Mr. Travers, have been marks of ownership, or they may have been intended to represent tutelary deities. The Maoris on the island appear, from what I learnt from a half-caste, to have a curious idea that the carvings were a sign that the Moriori race was doomed.

For my own part, I am inclined to believe that the human figures on the kopi-trees were connected with their burial customs, for in no other way does it seem possible to explain the peculiar attitude of all and the prominent ribs of some of the figures. "When dead," says Mr. Travers, "the arms were forced back against the chest and securely bound there with plaited green-flax ropes, the hands were bound together and drawn over the knees, and a stick was then inserted between the arms and knees. This was the orthodox method of trussing a body, and it was sometimes a work of great difficulty, for when the body became rigid the efforts of many men were required to bring it into a proper position. This being done, the dead was enveloped in plaited flax matting and interred as far as the knees, the upper portion of the body being invariably above the soil."

It seems tolerably certain that another method of disposing of the dead was by placing them in or against trees in the manner described by Mr. Mair. The particular mode of dealing with any dead body was probably determined by the character of the individual to whom it had belonged, and probably great importance was attached to the proper performance of the ceremony. The earlier methods of disposal may very likely have been given up for sanitary reasons on the advent of Europeans, a possibility which had struck me even before I came across the following significant passage from Mr. John Amery's work on the Chatham Islands, quoted by Mr. Travers: "In my rambles through the bush I have frequently observed a time- and weather-bleached skeleton grinning at me from some old tree. Walking one da with an ancient native woman, she suddenly stopped an

commenced an affectionate and whining *korero* with a skull suspended from a branch. I said, 'What old friend is that?' 'Oh,' said she, 'it is my first husband; he was a *tine pai*' (a good husband). My wife and I used both entreaties and arguments to break them from such indecent and unholy customs. One day, during my absence from home, a person was about to be interred in the usual manner. My wife, however, hastened to the spot and insisted upon having a deep grave dug. She was instantly obeyed, upon which she read an appropriate prayer, and the body was interred with decency. From that time the old custom was never revived."

If for any reason the Morioris really did abandon their ancient custom of tree-burial, it is not difficult to believe that they might, in place of the actual bodies, carve upon the bark of the trees those remarkable figures which are so clearly intended to represent skeletons. Such carvings would serve as a *memento mori* almost as well as the corpse itself, without the obvious disadvantages of the latter. There are several reasons why the kopi-trees should always have been selected for the carving. It is almost the only tree large enough, and, on account of the smooth nature of the bark, quite the most suitable; while, if there was any right of individual ownership in the trees, it is not unnatural to suppose that the effigy of the departed would be placed on his own property. This view of the case may also in some measure explain the Maori idea that the carvings indicated the doom of the Moriori race, for the abandonment of the ancient burial custom would probably be regarded as a most serious infringement of *tapu*, and as such would be expected to entail disastrous consequences. In this connection it is interesting to note Mr. Shand's statement that "the Morioris began to die very rapidly after the arrival of the Maoris, the cause of which they attribute to the transgression of their own *tapu*, for the Morioris were an exceedingly *tapu* race."

There are also rude rock-carvings on the island, but these are of quite a different type from those which I observed on the trees. At the entrance of a shallow cave at Mororoa the soft limestone rock is scored with bird-like figures in endless repetition (Plate V., fig. 5). These may possibly represent shags. Mr. Shand told me that a Moriori showed him two figures on the rock at Moutapu, which they say were the models from which all the bird-figures were taken; but they seem, according to the same authority, to have called the figures on the trees birds, so that there is doubtless some confusion here. I was also told by a lady on the island that she had found the figure of a shag carved on hard wood in a Moriori grave. Possibly the shag was regarded as a sacred bird.

Whatever they may have intended to represent, the Moriori idea of carving appears to have been extremely crude. The figures certainly were to a large extent conventionalised, but the inferiority to the workmanship of the New Zealand Maori, both in conception and execution, is, considering the undoubtedly close relationship of the two races, very remarkable. Taken in conjunction with their apparently complete ignorance of the art of tattooing, it certainly appears to indicate that the two races must have branched off from one another at a very remote period in their history, although the language appears to have undergone very little alteration.

As manufacturers of stone implements of various kinds the Morioris appear to have more nearly approached, if they did not equal, the Maori standard of excellence. Stone chisels of two very distinct types are met with. I give photographs of two specimens which were given to me on the island. Plate VI., fig. 10, represents a small chisel of yellowish chert, almost cylindrical in form, and with a narrow cutting-edge. This is probably one of those which Mr. Shand says were termed "*whao*," and which were used for making holes. Fig. 11 is a broad, flat chisel or adze of a hard grey stone, well polished; one side is quite flat, the other gradually bevelled to the cutting-edge, while the side edges have been ground flat. Rudely flaked chert "blubber-knives," such as are represented in figs. 8 and 9, are still common on the shore, but I was not fortunate enough to obtain any of the well-known stone clubs described and figured by Sir Julius von Haast.* Bone fish-hooks may be found amongst the sandhills. Figs. 6 and 7 represent a couple which I picked up in the neighbourhood of an old kitchen-midden, or shell-mound, at Maturakau; and sharpened pieces of birds' bones, used, as I was told, for extracting shell-fish from their shells, may be met with in similar situations (fig. 13). Sharks' teeth bored for stringing as ornaments (figs. 14 and 15) are also not uncommon.

One evening, whilst staying with Mr. Chudleigh at Wharekauri, I received an invitation from Mr. Abner Clough, who is employed on the estate, to visit him in his own quarters. Amongst the miscellaneous collection of articles which littered his table a remarkable-looking piece of whalebone at once arrested my attention. I found on inquiry that Mr. Clough had picked this specimen up in an old Moriori burial-ground amongst the sand-

* Haast, "On the Stone Weapons of the Moriori and the Maori" (Trans. N.Z. Inst., vol. xviii., p. 24). For further information concerning Moriori stone implements, see Shand (*Journal of the Polynesian Society*, vol. iii., p. 84 and Smith (*Op. cit.*, vol. i., p. 80).

hills on the shore near a place called Okawa, near Kaingaroa. The bone, which is represented in Plate VI., fig. 12, had evidently been carefully shaped and carved, and I had no difficulty in recognising in it a very typical example of that extremely interesting instrument of primitive races known to ethnologists as the "bull-roarer." Probably this bull-roarer is of ancient date, for the whalebone of which it is made is honeycombed with decay. Moreover, Mr. Shand had never heard of such an instrument existing amongst the Moriori; though this might readily be accounted for if, as in other races, the bull-roarer was a sacred article—probably, indeed, in the case of the Moriori highly *tapu*, for these people "possessed the *tapu* in all its forms and terrors" (Shand). The specimen is broad and flat, elliptical in cross-section, and remarkably short, with one end much broader than the other. The side edges are approximately straight, except for the notching to be mentioned directly, the broad end slightly excavated or curved inwards. The narrow end is a good deal worn with age, and has a deep notch in the middle, which may possibly be the remains of a hole through which a string may have been passed. The side edges are also deeply notched near the narrow end, evidently to allow of secure tying. Beyond these "fastening-notches" the edges are beset with smaller notches all along, and this notching is continued along the broad end. The broad, flat surfaces are also grooved. On the best-preserved side there is a pair of longitudinal grooves extending from end to end, one on each side of the middle line. In the region of the fastening-notches, which are a good deal broken away, these longitudinal grooves are crossed at right angles by two others. On the opposite surface, which has apparently been more exposed to the weather, only the two longitudinal grooves can be distinguished. The total length of the specimen is exactly 6 in., the breadth at the narrow end about 1½ in., and at the broad end about 2⅝ in. (6 by 1½ to 2⅝).

Much has been written of late years about the bull-roarer, which, as a toy, is familiar to many an English schoolboy. It is essentially a noise-making instrument. The schoolboy takes a thin wooden lath, notches the edges, ties a string to one end and whirls it round rapidly in the air. A peculiar humming noise is produced which is very suggestive of wind. In a specimen which I made recently I find that when humming, or "buzzing," the instrument also rotates rapidly about its long axis, and that unless it does so no noise is produced. Whether this rotation about its own axis is necessary in all cases I cannot say.

In a more or less typical form the bull-roarer is distributed amongst native races over perhaps the greater part of the

inhabited world. Professor Haddon has written an extremely interesting chapter on the subject in his work on the "Study of Man," and has there tabulated the uses and distribution of this remarkable instrument. It appears to have been used (1) as a sacred instrument in the mysteries in ancient Greece, on the west coast of Africa, amongst the Kaffirs, in North America, in the Solomon Islands, in Banks Island, in New Guinea, and in Australia; (2) in initiation ceremonies amongst the Kaffirs and in New Guinea and Australia; (3) as a summons to ceremonies amongst the Kaffirs and in North America and Australia; (4) to summon spirits in South America; (5) to frighten away spirits in North America and Banks Island; (6) as a god on the west coast of Africa and in Australia; (7) associated with judiciary powers, &c., on the west coast of Africa and in the Solomon Islands; (8) for producing wind amongst the Kaffirs, in North and South America, and in Torres Strait; (9) for producing rain amongst the Kaffirs and African Bushmans, in North and South America, in Torres Strait, and in Australia; (10) for producing thunder and lightning in North and South America; (11) as a charm in hunting or fishing by the African Bushmans, in Torres Strait, and in Australia; (12) for driving cattle by the African Bushmans and the Malays; (13) as a toy in the British Isles, Central Europe, amongst the Eskimo, in South America, amongst the Malays, in the Solomon Islands, in Banks Island, and in Torres Strait.

The bull-roarer was tabooed to women by the Kaffirs, the South Americans, the Solomon-Islanders, the Papuans, and the Australians.

In New Zealand it appears to have existed in a modified form, consisting of an oval flattened piece of wood without notches, but the use which the Maoris made of the instrument is not known. Professor Haddon observes, "It is also entirely wanting, so far as we know, from Polynesia, with the exception of New Zealand. It is worth bearing in mind that these islands were almost certainly inhabited by Melanesians before the Maori invasion,* and the bull-roarer may belong to the older population. A highly decorated specimen occurs in the British Museum; it was first figured and noted by Lang. We have no information as to its use." I may add to this that there is in the Canterbury Museum, at Christchurch, a bull-roarer made to order by a Maori from the Urewera country. This specimen is a flat ovoid piece of wood with smooth surface and smooth edges, quite unornamented, and

* Captain Hutton informs me that there is no sufficient ground for believing in a Melanesian occupation of New Zealand before the advent of the Maoris.—A. D.

with a hole through the narrower end for the attachment of the string. It is intended to be swung by means of a stick attached to the other end of the string.

It must be observed that the Maori bull-roarer is of a very different form from the Chatham Island specimen, so much so that one would hardly suppose the two to have been made by closely related races.

I also learnt from a European boy on Chatham Island that the bull-roarer is there known to the Maori school-children, presumably as a toy. This being the case, it might be suspected that my specimen is of recent origin, and not of Moriori workmanship; but its evident antiquity, its peculiar form, sculpture, and material, as well as the locality where it was found, afford pretty conclusive evidence that it is not of modern manufacture. The great difference between the Chatham Island and New Zealand bull-roarers perhaps affords another indication that the Maori and Moriori races branched off from one another at a very remote period.

EXPLANATION OF PLATES V. AND VI.

Plate V.

Fig. 1. Human figure cut in the bark of an old kopi-tree at Mororoa, Chatham Island.
Fig. 2. Similar figure at Wharekauri, Chatham Island.
Figs. 3, 4. Figures on two kopi-trees close together at Mairangi, near Wharekauri, Chatham Island.
Fig. 5. Figure of shag (?) carved in soft rock forming the entrance to a shallow cave or rock-shelter at Mororoa, Chatham Island.

(Figs. 1 to 5 from sketches by the author.)

Plate VI.

Figs. 6, 7. Bone fish-hooks.
Figs. 8, 9. Chert "blubber-knives" or scrapers (?).
Fig. 10. Cylindrical chert chisel.
Fig. 11. Flat chisel or adze of hard grey stone.
Fig. 12. "Bull-roarer" of whalebone.
Fig. 13. Bird's bone sharpened, and probably used for extracting shell-fish.
Figs. 14, 15. Sharks' teeth bored for stringing.

(Figs. 6 to 15 from photographs of specimens brought by the author from Chatham Island.)

ART. IX.—*A Philological Study in Natural History.*

By TAYLOR WHITE.

[*Read before the Hawke's Bay Philosophical Institute, 21st October, 1901.*]

PRIMITIVE man was a hunter of the beasts and birds. In Europe the climatic conditions were arctic; snow and ice extended from the far north even to the centre of France and Germany. Notwithstanding the rigours of the climate, various animals suitable to these conditions of life inhabited the outer margin of this great snow-cap. Man (as we see in the Esquimaux of the present time) was there also as a hunter of wild beasts, and as time went on he became herdsman and utilised the reindeer, as Lapps do even now. From certain osteological evidence as examined by scientists we know this to have been the case. To myself it seems also proved by philological deductions in the German language.

When the Roman general, Julius Cæsar, led his conquering armies through Gaul—a name which he gives to France and part of Germany—he noticed several strange animals in that country of which he had no previous knowledge, and which he mentions in his history of his battles and conquests. One animal he names *reno*, or *rehno*, which I consider to mean the reindeer, from comparing it with French *renne* and German *renn-thier* (a reindeer), also with German *renn-pferd*, a race-horse, *renn-hirsch*, a reindeer (literally, running- or race-stag, from *rennen*, to run); and *renn-schlitten*, a sledge, also abbreviated to *schlitten*, a sledge, is a suitable name for the vehicle to which the animal *renn-thier* was harnessed and utilised as a draught animal by his owner. The suffix or additional word *thier* in *renn-thier* is equivalent to beast or animal, which makes the whole word mean "run-beast" or "race-beast," and I see no cause for the special term *runner*, or *racer*, otherwise than as referring to the speed of the animal when driven in a sledge. The word *thier*, an animal, is the Teutonic form of our English word *deer*, which we use now as a general term for the *Cervidæ*, or stags, as in fallow deer or red deer. The word *fallow* is from Anglo-Saxon *fealu*, *fealo*, a pale-red colour; therefore we get the "pale-red beast" and the "darker-red beast" as the plain meaning of the two names. As to whether the German *rind*, cattle, *rinder-pest (rin-thier-pest)*, cattle disease, is connected with *rennen*, to run, I find no evidence, it being a word coined at a later date.

When the climate of Europe became more ameliorated or

temperate other species of deer occupied the land, coming possibly from the east and south. Julius Cæsar mentions an animal of Gaul under the name of *alces* (which is kindred to Russian *olene*, a stag; German *elch*, an elk or moose; French *elan*, an elk), probably a large stag or red deer. The Dutch colonists in South Africa name the largest of the antelopes *eland*.

Our English word *wild*—or, rather, its original form—is in German used to denote game (animals or birds which may be hunted), and occasionally is used in place of our word *deer*, as *roth-wild*, *roth-hirsch*, the stag or red deer (*roth* meaning red), *roth-huhn* (literally, red hen), the red-legged partridge; *schwarzes-wild* (black game), the wild boar; *wild-kalb* (literally, wild calf), a fawn or young deer; *wild-huhn*, a ptarmigan; *wild-sprossen*, antlers; *wild-stand*, a covert or game preserve; *wild-hirt*, a gamekeeper; *wild-bann*, right of hunting; *wild-e*, open moorland or uncultivated land, from which we derive English *wild-er-ness*. Another connection is *reh-wild*, a deer; *reh-bock*, the roebuck; *reh-geiss*, the doe or female of the roebuck. The terminal word *geiss* is a female goat, and *geiss-bock* is a buck goat, also a roebuck. *Reh-fleck* is a purple spot; *reh-fleisch*, venison; *hirsch-reh*, musk deer. In French *chevreuil* is a roebuck; *chevrette*, a roe or doe; *chevre*, a female goat. An assumed likeness in this animal to the goat is evident from its naming. Professor Skeat gives *roe* as a female deer; mid-English, *ro*; Anglo-Saxon, *ráh*; Icelandic, *rá*, &c.; derivative, *roe-buck*. An allied word is English *doe*, a female deer, and *doe-rabbit*, or *hare*. The German *dam-wild* and *dam-thier* look rather naughty words, but they are the neuter form for the fallow deer; *dam-bock* and *dam-hirsch* are the male, and *dam-geiss* or *dam-kuh* the female animals. This seems akin to Latin *dam-a*, a deer; French *daim*, a fallow-deer buck, *daine*, a doe. The English word *fallow* comes through Anglo-Saxon *fealu*, *fealo*, pale-red or yellow in colour. In French *fauve* is fawn-coloured or tawny: thus, *bête-fauve* and also *fauve* is fallow deer, which is equivalent to tawny-coloured beast. The English word *deer* is connected with Anglo-Saxon *deór*, a wild animal; Dutch, *dier*; Danish, *dyr*; Swedish, *djur*; Icelandic, *dýr*; Gothic, *dius*; German, *thier*; Latin, *fer-a*; Greek, *ther* and *pher*, a wild beast. German *thier* will not specially refer to wild animals, but rather to any animal, beast, or brute; in sporting, to doe. The following are examples: *Thier-arzt*, veterinary surgeon; *thier-garten*, zoological garden, or a park; *thier-kreis*, the zodiac (literally, the animal circle); *thier-kalb*, a fawn; *haus-thiere* (in the plural), domesticated animals (literally, house-animals, or animals kept in the vicinity of the house); *jung-thier*, a fawn (literally, young beast).

The Greek word $\theta\eta\rho$ (*thēr*), in an equal manner to the German *wild*, indicates specially hunting and the killing of *feral* animals, as *thera*, hunting, the animal hunted and caught; *therao*, to hunt; *therates*, a hunter or pursuer; *therion*, a wild beast; *theriodes*, savage, fierce. This word also, with varying suffixes, refers to the gladiatorial encounters with wild beasts within the enclosed area of the amphitheatre. English *hind*, the female of the stag, I would suppose to refer to the habit of the females composing the harem of the stag in following the lead of their lord and master—that is, in the meaning of *hinder* ones—Anglo-Saxon, *hind;* Dutch, *hinde.*

It is noticeable that to define the sex of many of these wild animals the term *buck* is used for the males, and *kuh*, cow, *kalb*, calf, is used, especially in the German or Teutonic, to define the female and her young; but we do not find any word equivalent to *bull* (German *stier*) to mean the male of any of the animals mentioned. At a later date, however, in America the male moose is called the *bull* and his consort the *cow*, yet they are of the order *Cervidæ*, and carry solid branching antlers, which are annually cast. The Germans have *renn-thier-kuh*, the female reindeer, but the use of *kuh*, a cow, could hardly originate in connection with a reindeer, for surely it must belong by right to the female of the ox. If so, the special definition of the sexes of the above animals must have remained in abeyance until after the knowledge of or the domestication of the ox. But, if so, why not also the use of an equivalent to *bull* to denote the males, as in the bull, cow, and calf of the whale and seal? If used to the walrus, we would have whale, horse, bull, &c., from *ros*, a horse. In place of *bull* we get *buck* or *boc*. Now, this name certainly is an original term for the male goat. In German *geiss* and *zeigel* both mean the female goat, to which is added the suffix *bock*, to mean the male; at the same time German *bock* is a male goat, and we find its variants in Anglo-Saxon *bucca*, Dutch *bok*, Icelandic *bukkr*, Danish *buk*, Welsh *bwch*, Gaelic *boc*, and even Sanskrit *bukka*. And English *butcher* comes through mid-English *bocher*, French *boucher*, originally meaning "one who kills goats," from old French *boc* (French, *bouc*), a he goat. These people, therefore, must have known and held in domestication the goat previous to the use of the word *buck* to denote the male of different species of *Cervidæ*, and, in fact, the use or equivalent of the German *wild* must have been greatly modified since first coined, unless we are to come to the conclusion that those people using it to mean feral animals had already several kinds of domestic or tame animals, and we might also say birds, meaning the specially tame bird *Gallus domesticus* (the cock and hen of our poultry-yards—*hahn* and *henne* of

the Germans; *huhn*, a fowl; connected by Skeat with Latin *can-ere*, to sing, from its noisy habits, or crowing).

To further point this: In English we have such names as *moor-hen*, *water-hen*, black-cock and his female the *grey-hen*; and we have brought this custom to New Zealand in calling *Ocydromus* the wood-hen. Again, in the name of one of the two ships of Tasman's expedition when he discovered New Zealand we get *Zee-hahn*, or sea-hen, a name of a kind of sea-bird; we have also named a large petrel *cape-hen*, mostly seen when a vessel is rounding Cape Horn. You will observe that we speak of a *wood-hen* or a *cape-hen* without consideration as to whether it is male or female—the comparison is simply between these birds and the domestic fowl of our childhood's knowledge. Notice, also, our term for the stormy petrel, one of the smallest (perhaps the smallest) of the birds of the ocean —"Mother Carey's *chickens*." These little black-and-white birds are most persistent in following in the wake of sailing-vessels.

Here are several other German words, or names of wild fowl, which are compounds of the term *huhn*, the neuter form, of *hahn*, the masculine form, and of *henne*, the feminine form, of *Gallus domesticus*, our barn-yard fowl, which are extremely suggestive of the question as to whether these people owned the tame form of *Gallus bankiva* or whether the bird at some later time became known as the cock and hen *par excellence*, as the king and queen of all birds. German *au* and *auer*, a plain or meadow; *auer-weit*, extended as a plain, *weit* in composition meaning far or wide; *auer-wild*, the grouse, and so equal to moorland game; *auer-hahn* (male) and *auer-henne* (female) in my dictionary is given as both grouse and woodcock, which must be an error, for *wald-schnepfe*, or wood-snipe, is evidently the woodcock. A second meaning given is "the grouse," but a scientific correspondent once wrote me that the capercailzie, or cock of the woods, was *ur-hahn*, now written *auer-hahn*, the former name being latinized in its generic title as *Uro-gallus*, the meaning being "the original cock, or cock of yore," as if in contradistinction to *Gallus domesticus*. The German *ur* in compound words=primitive, primeval, original; *ur-ahn*, great-grandfather; therefore *ur-huhn* would be the first or original, or perhaps, rather, the fowl of that country to which the immigrants came. I would rather accept the form *auer-hahn*, or moorland cock, but was it not a bird of the forests? The name *capercailzie* is said to come through Gaelic *capull-coille*, great cock of the woods (literally, horse of the wood, from Gaelic *capull*, a horse, *coille*, *coill*, a wood).

Also in German we have *wild-huhn*, the ptarmigan, wild or game fowl; *reb-huhn*, the vine fowl, or partridge; *birk-hahn*,

the birch (tree) cock, the black cock; *birk-henne*, said to be the red-grouse, but must be the grey-hen, the female of the birds we name black-game; *kurre*, a turkey-hen; *kurr-hahn*, a turkey-cock. It may be of interest to make a guess how the English came to use the word *turkey* to designate this bird. I would say that the red head and curiously elongated caruncular tassel, also of scarlet hue, gave the fancied resemblance to a Turk and his scarlet fez, or cap. This bird, originating from North America, has no other connection with the Turk, except as supposing the use of the diminutive form *Turk-ie*, or little Turk. We also have *wasser-huhn*, the moor-fowl, and *wasser-henne*, the water-hen.

Following the word *cock* into the French language, we have *coq*, the male *Gallus domesticus; coq-d'Inde*, cock of India (*i.e.*, American Indians), a turkey-cock; *coq-de-bruyère*, cock of the heather, the grouse; *coq-a-queue-fourchue*, the cock with the forked or branching tail, which is very descriptive of the black-cock, whose tail-feathers bend outward to either side somewhat in the form of two J's placed back to back: thus, ⌉⌈. The woodcock is *coq-des-bois*, or cock of the woods, and *coq-de-combat* is a game-cock, which in German is *kamph-hahn*. This latter is also the name of a small bird, the ruff, which is allied to the plover, and is sometimes kept in captivity on account of its great pugnacity towards others of its kind. The female, being without the neck-ruff, we name reeve. *Kamph* means "combat" or "conflict," as *kamph-hahn*, battle-cock.

The French word *coquerico* means cock-a-doodle-do, and is on the same lines as *coquette*, a flirt; *coqueliner*, to crow, to run after the girls. In Sanskrit *kukkuta* is a cock, probably so called from the call of the bird. As the bird carries his voice to all countries, we may expect to find in most cases it is named therefrom, as, for instance, Malay *kukuk*, the crowing of cocks; *kakak*, the cackling of hens. In French the female bird is named *poule* and *poule d'Inde*, hen of India (North American Indians), the hen turkey. You will remember that the early voyagers, on reaching the coast of America, supposed they had reached India, hence the name of West Indies. The natives of America were thus misnamed Indians, and the term became so much in use that Captain Cook and others wrote of the aborigines of the islands of the Pacific Ocean as Indians, even the Maori of New Zealand being so named. *Poule d'eau* is the moor-hen, and is also termed more correctly *water-hen*. *Poule* would seem allied to Latin *pull-us*, young animal or foal; English derivatives, *pullet*, a young hen; *poultry*, and others.

Cochon d'Inde, the pig of India, is the guinea-pig, and is a native of South America. The same derivative is disguised in

French *dindon*, a turkey-cock; *dinde*, a turkey-hen; and *dindonneau*, a young turkey. German *meer-schwein-chen* (literally, "sea-pig-small") is a guinea-pig—probably small pig from over the sea. But a guinea-fowl is called *perl-huhn*, pearl fowl, most likely from the circular white spots on the feathers. *Meer-schwein* is the porpoise, the English name of which is said to be from Latin *porc-us*, a pig, and *piscis*, a fish. Another example of the application of the terms *cock* and *hen* is seen in English *peacock*, *peahen*, *pea-fowl*; German, *pfau* (male), *pfau-henne* (female: note the suffix *henne* as approximate to English *hen*), *pfauge-flugel* (pea-fowl); French, *paon* (male), *paonne* (female), *paon-sauvage-des-Pyrénées* (the ruff and reeve mentioned above: why called *paon* I do not understand, perhaps from spreading ruff feathers on the neck of the male bird, but note its fighting qualities in *sauvage*); Latin *pavo*; Greek, *taos* and *taon* (a peacock). Skeat connects with Tamil *tokei togei*, a peacock; this might well be called "the bird of India," but is not so named. Some years ago, when I was called upon to assist in the amusement of some children on a wet day, the entertainment consisted of each person present taking the name or *rôle* of some animal or bird. One small girl elected to be a peacock, and as the narrator of the story to the play arrived at the word "peacock" the child, in a peculiar tone of voice, cried out *pa-oo*, making the two syllables in a somewhat different tone. At once I saw the similarity in this perfect imitation to the call of the bird to Latin *pavo*, and am satisfied that the voice of the bird originates its own name.

French *coq*, a cock, would seem connected with the Greek κοκκυξ, a cuckoo, as seen in κοκκυζο, to crow like a cock, to call as the cuckoo. As an ally Skeat has *cockatoo*, a kind of parrot, from Malay *kaka-tua*. This latter is evidently seen in the Maori *kaka* (the *Nestor meridionalis*, a species of parrot), and in *kaka-riki*, a parrakeet (literally, a small *kaka*). From the plumage of this bird comes the standard for the colour green; also *kaka-riki*, green colour; *kaka-po*, the night parrot, from *po*, night. The name for *Gallus domesticus* among the Polynesians is *moa*, but when Captain Cook brought the fowl to New Zealand the name *moa* was then used to denote different varieties of *Dinornis*; so seemingly the Maori has invented two different original words founded on the call of the bird. The word *hen* Skeat connects with Latin *can-ere*, to sing, Anglo-Saxon, *hana*, a cock (literally, the singer)—as I have already indicated.

Whatever may be the origin of the words *cock* and *hen*, it seems to me from the above study that before man took the thought to distinguish between the sexes of birds and animals he had already domesticated the *Gallus bankiva*, now found

chiefly in the forests of Hindustan, and also herded or held in captivity the goat and the ox—that is, judging from European languages. The domestic fowl seemingly was by its Latin name *gall-us* introduced to the south of Europe by way of Gaul, or France. (Note the German word *Gallien*, Gaul. How do we derive the term *Gallic cock* in reference to the French?)

In Latin the two words *bestia* and *bellua* originally had special reference to wild beasts, but these same words in other languages, and through changes brought about by lapse of time, now have reference to domestic cattle. In Latin *bestia* is a beast, an irrational creature, in opposition to man, while *animal* includes man and all living things. *Bes iarius* is one who fought with wild beasts in the arena or or circus, as a public entertainment. If we follow *bestia* into Greek we come back to words already referred to—*therion* and *ther* (*bestialis*=*theriodes*). In French, by elision of letter *s* and change of pronunciation, we have *bête*, a beast, which, with the addition of either of the kindred words *feroce* and *sauvage*, means a wild animal. *Bête*, in conjunction with distinguishing terms, has reference to domestic animals, as *bêtes-à-laine*, sheep (beasts having *laine*, wool); *bête à cornes*, horned beast; *bête de somme*, beast of burden; *bête de Vierge* (of the mother of our Lord), the ladybird (beetle); *betail* (plural, *besti-aux*), cattle; *gros betail*, large cattle; *menu betail*, small cattle; *exposition de betail*, cattle show. In Italian *bestiame* is cattle. *Gros-betail* is elsewhere said to be neat or black cattle, so I suppose *menu-betail* to be sheep and goats.

From our other Latin word—*bellua*, a wild beast—we get: Latin, *bell-um*, war; English, *bell-i-cose*, the desire of battle, and *bell-ing*, the challenge call to fight of stags and their allies during the rutting season; German, *bell-en*, to bark, to grumble, and *brüll-en*, to bellow. We also get: English, *bell*, a hollow piece of metal for producing a loud noise or sound, and *bull* (the beast); mid-English, *bellen;* Anglo-Saxon, *bellan*, to make a loud noise; Icelandic, *belja*, to bellow; German, *brüll-frosch*, a bull-frog, *brüll-ochs*, a bull. English *boulder*, a large water-worn stone, so named from the noise made by these stones when driven by flood-waters along the bed of a river or stream, is in Sweden *buller-steen;* Swedish, *bullra*, to thunder, roar, and *steen*, a stone; in Danish *ld* for *ll* gives *buldre*, to roar, and *bulder*, a crash. *Bull*, as the bellowing beast, is shown in old French *bugle*, a wild ox; French, *beugle-ment*, a bellowing; English, *bugle*, which is short for *bugle-horn* (compare English *cornet*, a horn, also a wing of a troop of horse led by a cornet or bugle, also an officer of such troop; Latin *cornu*, a horn); because the horns of oxen were in old times used as loud-sounding

instruments, we have a hunting-*horn* or huntsman's *horn*, which he blew in the chase; a *horn* of beer could be obtained (or asked for) when I was a small boy; the larger portion of a horn with a wooden bottom let in was the drinking-cup of our ancestors. The word *bull* is not found in Anglo-Saxon, but its derivative or diminutive is *bull-uca*, a *bull-och*. I am unable to trace the suffix *uca* or its later form *och*, which has certainly no connection with German *ochs*, an ox. Possibly the same terminal diminutive is shown in Latin *bu-cula*, a heifer, from *bos*, an ox, bull, or cow. A kindred word to *bucula* seemingly by inference is found in the Latin *buccina*, a trumpet or crooked horn: note German *bügle*, curve, anything bent, *bügle-riemen* stirrup-leather; *tuba* being the name of the straight trumpet. This word is also written *bu-cina*, which would seem the correct form though seldom used. The confusion is owing to close similarity to *buccula*, the diminutive of *bucca*, a cheek or mouth, and *bucco*, one who has the cheeks distended. Here may even be a connection, for a person occupied in blowing a horn has the cheeks puffed out. In Italian *buccina* is a trumpet; *buccin-are* is to proclaim with sound of the trumpet; and *buciacchio* is a bullock. In French *bou-villon* is a bullock. The proof of the argument is in Latin *bucerus*, having horns like an ox; Greek, *bou-keros*, having bulls' horns (from *bous*, a bull, and *keras*, a horn).

But to return to the consideration of Latin *bestia*, a beast, or wild beast. Through the French *besti-aux*, cattle, we probably have adopted the use of the term *beast* and *beasts* in reference to our domestic oxen—that is, to our horned cattle; for in our form of speech we make no provision in the generic term for the polled races of oxen, such as the Angus and Galloway breeds, originating in Scotland.

As an illustration I will give a clipping from a newspaper report of the annual fair at Ipswich in May, 1891, curiously called "St. George's Fair": "Fat beasts not quite so numerous, but buyers attending in strong force: a decided improvement in values was noticed. Fat sheep and lambs in request, and recent prices maintained. Numbers at market: Beasts, 1,359; sheep, 2,815; swine, 759. Messrs. Day and Sons, of Crewe, advertise 'zomo-sal,' a saline blood tonic for horses and beasts." And also the following from the "Live Stock Journal" of the 28th June, 1901, under the heading "Scraps": "Plough cattle were not expensive in 1310. At Cardiff two beasts bought for a cart cost only 18s.; twenty-three plough-oxen cost 13s. 4d. per head; while a bull and fourteen cows bought to stock a manor cost 10s. per head." And this from an English newspaper: "Spalding, Tuesday.—A small show of fat beasts and a slow trade, 7s.

per stone being the top price. Store beasts sold rather better in proportion. Small supply of mutton, and trade hardly so good. From 6d. to 8d. per pound was realised. Good trade for pork, which was in demand at 6s. to 7s. per stone, according to quality."

In prehistoric times, and even down to the date of Julius Cæsar's conquest of Gaul, there existed in Europe two species or varieties of the ox, living in a wild state in the extensive forests, named *Bos primigenus* and *Bos longifrons*, and their fossil remains are even found in Britain. The *B. primigenus* is considered by most naturalists to be the progenitor of the larger breeds of domestic oxen, and it is generally considered to be the great beast *ur*, mentioned by Cæsar in the history of his wars. Cæsar thus describes them: "These *uri* are little inferior to elephants in size, but are bulls in their nature, colour, and figure. Great is their strength and great their swiftness; nor do they spare man or beast when they have caught sight of them. These when trapped in pitfalls the hunters diligently kill. The youths, exercising themselves in this sort of hunting, are hardened by the toil, and those among them who have killed most, bringing with them the horns as testimony, acquire great praise. But these *uri* cannot be habituated to man or made tractable, not even when young. The great size of the horns, as well as the form and quality of them, differs much from the horns of our oxen. These horns, when carefully selected, they ring round the edges with silver, and use them for drinking-cups at their ample feasts."

In speaking of the untamable disposition of the young of the *ur*, it seems probable that the character and well-known disposition of another ally of the *Bovidæ* is confused with it—namely, the European bison, which is known in Germany as the *aur-ochs*, or *auer-ochs*, the latter of the two names appearing the more correct form, as meaning "the moorland-ox, the ox of the uninhabited or uncultivated land." This animal is still preserved by Royal edict in Lithuania, and is also found among the hills and valleys of the Caucasus. It is there called *zubr*, a name which, curiously enough, contains the letters *ur*. This name *ur* is assumed by many to be the German prefix *ur*, ancient, or original; but if that were so it would seem necessary to use the suffix "*ochs*," and so get *primeval* or *ancestral ox*. But my German dictionary also gives *ur* as the *ure-ox* (masculine) without the suffix *ochs*. So the Germans seemingly have two separate names for the bison, and that of *ur* for *Bos primigenus*. Now, *ure* is French, and is translated as the *ure-ox*, the *urus* (also of male gender). The German *ur* as a prefix gives *urahn*, great-grandfather; *ur-alt*, very ancient, primeval; *ur-all*, the

universe. *Auer-ochs*, a bison, is also male, as of a wild beast whose sex is immaterial. Why is this? And note *auer-weit*, extended as a plain; *weit*, wide, broad, extended, far off, distant. We have already met the prefix as in *auer-hahn*, when treating of the wild game, and so may take *auer-ochs* to be "the ox inhabiting the moorland or open country" (the bison).

We have seen that great use was made of the names of the domestic fowl in naming the sexes or quality of game birds, and the use of *boc*, a male goat, to indicate sex in certain animals in the German—*cow* and *calf* being the opposite terms—but we have in no case met with the use of *bull* as a sexual denominative, though in English we find *bull-moose*, *bull-whale*, and probably *bull-wal-rus*, which latter word, when analysed, gives *bull-whale-horse*—German *ros*, a horse. In English *buck* is used as the mate of the doe among smaller kinds of deer and the male of the goat. Can it be possible that the great beast *ur* was the wild bull, which came and served the domestic *kuh* (cow)? The bull, being of dangerous habits and of a roaming disposition, could not be attached to one place, or be safely held in captivity. He was *bellua*, the bellower; *bestia*, the beast; *fer-us*, *thier*, the wild animal. He was the *ur*, *thur*, *tur*, *taur-us*—German *stier*, a bull; *stier* possibly stood for *sta-thier*, the beast confined in a *sta-ll* or *sta-ble*—Latin *sta-bulum*, a stable, from *stare* (for *sta-are*), to *sta-nd*, the animal being kept *sta-tion-ary* or confined, or shut up in a sty, as seen in pig-*sty*. According to Skeat *taur-us* is used for *sta-ur-us*.

In Scotland *stirk* is a calf not yet a year old, and is probably derived from the animal being shut up in a pen or sty away from the cow, or as a hostage for the return of the cow, or that the owner might secure the first of the milk. The word is possibly connected with Latin *stirc-us*, dung, owing to being dirty from its enclosure. But in the Caucasian Mountains *tür* is the ibex (*Caper caucasica*), and, I understand, is used also for *Caper ægagrus*, the supposed original wild form of the domestic goat. A similar sound is in *thar*, a native name for *Hemitragus jemlaica*, a kind of wild sheep. Note also *chimerical*, from Greek *ximaira*, a she goat; also the *chimæra*, a fabulous monster slain by Bellerophon. In the Doric *ximaira* denoted a young she goat under a year old. Compare English *gimmer*, a female or ewe lamb not a year old. Possibly all these words may have meant "the wild animal" originally.

To return to the goat. At the present time it is a surprise to find that our word *tragedy* is derived from the Greek word *trag-os*, a he goat, through *trag-odia*, tragedy (literally, "goat-song," from Greek *ode*, a song or ode); *trag-ic*, from Greek

trag-ikos, literally *goatish*. One authority gives the explanation that a he goat was the prize given for the best tragic poem in a competition, "probably," as Professor Skeat says, "because a goat (as the spoiler of the vines) was sacrificed to the Greek god Dionysus (Latin, Bacchus)." This latter theory, however, will not explain the connection between a goat and the tragic poem.

It is worthy of note that, in the German, *zeigel* and *geiss* are used in the feminine only, as denoting the she goat, as though they, being the more numerous members of the flock (fifty to one against the male animal—*bock*), gave the designation to the species. In olden times the males of the flock were chiefly killed for food, which is well shown in the Bible stories of entertainment of visitors and sacrificial rites. Observe the following: *Zeigel-bock* and *geiss-bock*, a male goat; *geiss-rebe* = goat-vine, the honeysuckle—*i.e.*, the climber: perhaps from this Professor Skeat connects the goat and the vine, as "the spoiler of the vines": also *geiss-blatt* ("goat-leaf"), the honeysuckle; *geiss-melker*, the bird goat-sucker or night-jar, in French *tette-chèvre*, teat goat.

The goat being the earliest of the truly domesticated animals tamed by man, gives us the word *butcher*, through French *bouc*; old French *boc*, a male goat; French, *bouch-er;* mid-English, *bocker*, a butcher (literally, "one who kills goats"). The name *bukka*, a goat, extends even to the Sanskrit; but in German a butcher is *fleischer, fleisch-hacker*, and *fleisch-hauer*, derived from *fleisch*, flesh or meat.

In the word *pheasant* we are reminded that this game-bird was of comparatively late introduction to the forests of Europe, the name being derived from Phasis, a river in Colchis, to the east of the Euxine or Black Sea.

The domestic fowl is said to have reached Europe 600 B.C., but was domesticated in China 1200 B.C., and it is remarkable that the sexes of other birds should in many European languages be named after those of the domestic fowl. As the goat denoted the sex in certain animals, so the use of *cock* and *hen* signified the sexes of birds.

II.—ZOOLOGY.

Art. X.—*On the New Zealand Lamprey.*

By Arthur Dendy, D.Sc., Professor of Biology in the Canterbury College; and Margaret F. Olliver, M.A.

[*Read before the Philosophical Institute of Canterbury, 6th November, 1901.*]

The lamprey has been found in New Zealand in three well-marked stages of growth—the *Ammocœtes*, the larval form, very similar to the corresponding stage in the European lamprey; the adult *Geotria*, with a well-developed gular pouch; and the *Velasia*, a form intermediate between the other two, with no gular pouch. Little is known of its life-history or habits; but in October the *Velasia* come up some of the rivers in shoals, and are caught by the Maoris for food, and the Maoris say that they come down again in December with gular pouches. Very few specimens of any stage have hitherto been preserved, but recently a large number of *Velasia* were sent to us alive from the Mataura River, up which they were making their annual migration, and as regards this stage we were able to work from the fresh material.

Both the *Velasia* stage and the adult *Geotria* were first described by Gray in 1851, and were classified by him as distinct genera (*Geotria* and *Velasia*) of the family *Petromyzonidæ*. Günther, in 1870, ranks the two forms as separate species of the genus *Geotria*; the pouched form he calls *Geotria australis*, and the *Velasia* he calls *Geotria chilensis*, since *Geotria* in the *Velasia* stage was first discovered in Chili. Recently Ogilby, in reclassifying the Australian lampreys, reverts to Gray's system of classification, and places the two forms in different genera.

Before minutely examining the animals themselves it had occurred to us that possibly, since the larval *Ammocœtes* was formerly regarded as a separate genus, a similar mistake had been made in the case of the *Velasia*, which might be only an intermediate form (since it was only found in New Zealand, Australia, and Chili, where the *Geotria* was also found), and that, if *Velasia* and *Geotria* actually were distinct species, it

was impossible to account for some forms which have been found intermediate between the *Velasia* stage and the adult. Günther himself, in speaking of one such form, suggests that *Velasia* may possibly develope a gular pouch later in life, in which case the distinction between the two forms would be doubtful. Ogilby, however, as already noted, actually reverts to the idea of a *generic* difference between the two. The distinctions upon which the old classifications were based are merely external ones—the shape and size of the oral disc, the position of the teeth, the presence or absence of a gular pouch, and the shape and position of the fins.

In the *Velasia* stage the head is small, the oral disc is round and small, and the teeth are closely packed together in rows, whilst in the adult *Geotria* the head region is enormously developed, the oral disc being very large and flattened on the lower margin, owing to the growth of the gular pouch below it; and the teeth, which, as we have ascertained by careful examination, correspond in number and position to the teeth of the *Velasia* form, are some distance apart, owing to the growth of the disc between them. The gular pouch is, of course, only fully developed in the adult *Geotria*, but intermediate forms have been found possessing a slight gular pouch.

There is no very great difference between the fins of the *Velasia* and the adult. They are larger and situated relatively farther forward in the *Velasia*, but they change gradually with the growth of the animal, and we have a series of four specimens which exhibit the different conditions of the fins at different stages in life.

Fourteen specimens of the *Velasia* which were dissected were found to be sexually immature, males and females, whilst the only two pouched forms which we have dissected are sexually mature, or nearly so. None of the former observers appear to have examined the internal anatomy at all, but have drawn their conclusions from the external differences, probably because of the scarcity of material at their disposal.

In other respects the *Velasia* closely resembles the adult, but is longer and thinner. We could not compare the living forms, as we have not yet been able to obtain a fully grown *Geotria* alive, and we find by experiment that spirit-preserved specimens undergo considerable shortening.

As the two generic names *Velasia* and *Geotria* have been applied to the same animal, we have had to decide which to retain, and, following Günther's nomenclature, we propose to call the adult form *Geotria australis*, and to use the term "*Velasia*" to distinguish the intermediate form, just as the term "*Ammocœtes*" is still used to distinguish the larva.

Thus it appears that, whereas the northern lampreys of the genus *Petromyzon* undergo only one metamorphosis—namely, from the *Ammocœtes* to the adult—the southern form (*Geotria*) undergoes two well-marked changes, from the *Ammocœtes* to the *Velasia*, and then from the *Velasia* to the adult, which latter represents a further stage in development never reached by the northern forms.

ART. XI.—*Note on an Entire Egg of a Moa, now in the Museum of the University of Otago.*

By W. B. BENHAM, D.Sc., M.A., F.Z.S., University of Otago.

[*Read before the Otago Institute, 11th June, 1901.*]

Plate VII.

FRAGMENTS of moa eggshell and more or less complete eggs have long been known, but the acquisition of an absolutely uninjured egg is of some interest, both on its own account and on account of the manner in which it was obtained. As far as I am aware, no entire egg is on exhibition in any museum. The specimen obtained at Kaikoura was injured by the pick in excavation.

The egg which forms the subject of this note was secured by a dredge-hand on the Earnscleugh gold-dredge, working on the River Molyneux, Otago.

The bank of the river is composed of very fine river-silt, and was formerly cultivated as a farm. It is so fine that when dug and dried it soon becomes reduced to fine powder, and is blown away in impalpable dust. The river, especially when in flood, scours the bank considerably, and it was after such a scouring, and when, fortunately, the dredge was not actually at work, that the egg was set free from the silt, and, floating in the river, drifted into the "well" between the two pontoons of the dredge. Luckily it was observed floating here and secured by one of the men, who also noted the hollow in the bank left by its removal, at about 14 ft. below the surface of the ground.

The egg was acquired for the Otago Museum through the kind services of Mr. Alexander Black, of Dunedin, who obtained it from the dredge-hand for £50, towards which Mr. Black himself and the Otago Institute contributed £5 each, while the balance was paid by the University.

It is not my intention to enter into a detail account of the structure of the eggshell, but I append references to literature in which these details will be found.

The present egg has the usual pale-buff colour. The surface is more or less worn or dissolved away by the action probably of the water passing through the soil; and, in comparison with various fragments of eggs from elsewhere, the surface is not shiny, though worn smooth, but over two areas at opposite ends of the equator the surface is fairly perfect. It is here marked by numerous small pits and short linear furrows of various lengths and depths (*vide* Hutton), but averaging 1 mm. in length. They are irregularly arranged, but always disposed lengthwise. There are about twenty such furrows to the square centimeter, and about as many pits; but the relative numbers vary in different parts, for by comparing this complete specimen with other less perfect eggs, in which the surface is not weathered, it appears that the pits are rather more numerous towards the poles and the linear furrows round the equator. In shape this moa's egg is relatively longer and narrower than that of an ostrich, and in this particular specimen one pole is slightly larger than the other; but in this matter there appears to be some variability in moas' eggs. I have seen others in which the two poles are precisely alike. The following measurements were taken: Length between vertical uprights, 195 mm. ($7\frac{3}{4}$ in); breadth between vertical uprights, 135 mm. ($5\frac{1}{4}$ in.); greatest circumference, 522 mm. ($20\frac{1}{2}$ in.); lesser circumference (equatorial), 428 mm. ($16\frac{7}{8}$ in.); weight, 286·5 grammes.

I had an opportunity of examining a second entire egg, which was obtained some months later by the same man about a hundred yards below the spot at which our specimen was taken. The egg had been dipped in shellac (?), and was in a very dirty condition when it was brought to the Museum in order that the taxidermist might clean it before its transmission to London for sale. He refused, however, to undertake the responsibility. I took the following measurements, from which it will appear that this second egg was rather larger than our specimen; the two ends were similar, so that the egg was a perfect ovoid: length, 201 mm.; breadth, 138 mm.; greater circumference, 540 mm.; lesser circumference, 440 mm. I did not weigh it.

Both these eggs, as well as two or three other more or less damaged specimens that have been through my hands, appear to belong to the same species of moa, if we may judge from their agreement in dimensions. As the commonest genus in Otago was *Euryapteryx*, we may safely regard some species of this genus as the parent. It would be dangerous, however, to attempt to indicate the species, for size of egg is no guide to

size of bird, as we know from the extraordinary disproportion between the great egg and the small body of the kiwi; but I think we may go so far as to say that this egg was laid by either *E. ponderosus* or *E. elephantopus*.

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EXPLANATION OF PLATE VII.

Photograph of moa's egg (reduced).

ART. XII.—*An Account of the External Anatomy of a Baby Rorqual* (Balænoptera rostrata).

By W. BLAXLAND BENHAM, D.Sc., M.A., F.Z.S., Professor of Biology in the University of Otago.

[*Read before the Otago Institute, 11th June, 1901.*]

ON Monday, 6th August, 1900, I was informed that a "young whale, about 12 ft. long, had been cast ashore on the beach outside the Otago Heads." It was offered to me for a sum of money, and I arranged to purchase it. It turned out to be a young rorqual, about 10 ft. long overall, in excellent condition, the skin being damaged here and there, partly from being handled no doubt, partly from being cast ashore. On Tuesday I had photographs taken of it in various positions, and, with the help of Mr. Hamilton, made measurements and observations on its outer anatomy. On Wednesday I had a mould taken of it, and was able to commence dissection on

that afternoon while the cast was being made. The cast is now exhibited in the University Museum.

Colour: In its general colouration it agrees pretty closely with the description given by Von Haast (Trans., xiii.). The upper surface of head and back is dark-grey—practically black, including dorsal fin and dorsal surface of the caudal fluke. The belly is pure snow-white (which after exposure to rain and air during twenty-four hours became a bluish-white). The lower jaw is very dark-grey, fading rapidly to white a few inches below the gape. Behind the angle of the mouth the colour is paler grey. The pectoral limb dorsally is grey, deepening to black along the posterior margin; but the tint gets lighter towards the anterior margin, which is white. The line of junction between grey and white is about on a level with the mouth, the base of the pectoral limb, and the caudal fluke. But the tone of the grey varies: Above the base of the pectoral are wavy lines of dark and light grey, obliquely vertical, with the upper ends directed backwards, one of which is particularly noticeable, starting from the axilla upwards and backwards; a second, more or less parallel to this, lies above the base of the pectoral. About midway along the body the darker tint is more extensive, invading the generally lighter grey, so as to form an irregularly oval darker patch about midway between pectoral and dorsal fins.

Mouth: The roof of the mouth is bright-pink; the baleen, which forms but a narrow band on each side—only about $1\frac{3}{4}$ in. broad at its broadest—is purplish-pink for about half its depth, the free ends—that is, about lower half—being pink. But during the day these colours changed to pink and almost white respectively. The base of the baleen is yellowish.

The tongue is pink; the back of mouth pink, with a few black pigment spots. The tongue itself is margined laterally along the region that is free (which is 8 in. in length) with thin fleshy folds, irregular in shape and size, vertically disposed, overlapping one another; soft, flexible, and no doubt an aid in capturing food.

Hair: There are about fifteen hairs on each side of the face, and evidence, in the presence of follicles, of five or six more. On the chin, or anterior rounded extremity of the lower jaw, are two vertical rows of hair-follicles, from most of which a single short white hair protruded. Each pit is very distinctly marked, owing to the very dark-grey colour round its margin. The two rows, one of which presented seven the other eight follicular pits, are about $\frac{1}{4}$ in. apart, though the upper pair of pits are distinctly more widely separated. There is a space of about $\frac{1}{4}$ in. between each pit of a vertical row. The bristles, of which I counted six on the right and four on the left side, issuing from the upper pits of

each row, are about $\frac{1}{8}$ in. long. Along the upper and lower jaws is a horizontal series of similar white hairs of larger size. Along the upper jaw is a row of four bristles, and two or three black hairless follicular pits anteriorly. The first hair is $8\frac{3}{4}$ in. from anterior end of the snout, the last $15\frac{3}{4}$ in., and the series lies about $1\frac{1}{2}$ in. above the lower margin of jaw. The hairs on the lower jaw constitute a row of five bristles, the first of which is 10 in. from the anterior end, the last $15\frac{1}{2}$ in. The row slopes downward posteriorly, so that, while the first hair is $1\frac{1}{2}$ in. below the upper margin, the last is $5\frac{1}{2}$ in. below. The hair is $\frac{1}{2}$ in. in length. This line follows, more or less accurately, the line of junction between grey and white. The spaces between bristles, starting from anterior end of series, are: $1\frac{3}{4}$ in., $2\frac{3}{4}$ in., $1\frac{1}{2}$ in., $1\frac{1}{2}$ in.

The baleen is coloured as above. Each row forms an elegant curve close to the outer margin of the roof of the mouth. The right and left rows nearly meet anteriorly, where each is very narrow and the baleen short. The rows then diverge, following the outline of the jaw, but behind the angle of the gape curve inwards for a short distance. The total length of the row, measured in a straight line, is 1 ft. 9 in. The greatest distance separating the rows is $6\frac{1}{4}$ in. This, then, is maximum width of palate. The greatest length of baleen is $4\frac{1}{4}$ in., and this is not the outermost margins; the breadth is $1\frac{3}{4}$ in., which is retained for greater part of course.

The animal was a young female, and had not long been born, as the navel was a slit-like depression 2 in. long and about $\frac{1}{2}$ in. deep, with vascular walls; it is situated 5 ft. 4 in. from tip of lower jaw. On each side the skin shows a pink patch a short distance above the navel. The navel is situated in an oval or diamond-shaped area with rounded angles, limited by a shallow furrow, and from the posterior angle a distinct furrow passes backwards to the urino-genital depression, or vulva, which lies 1 ft. 5 in. behind it.

This vulva is slit-like, the lips being close together; but this slit, which is $6\frac{1}{2}$ in. long, bifurcates posteriorly, leaving a small triangular area, which is the base of a ridge which can be traced forwards into the vestibule. On pressing apart the lips a deep depression is visible, the bottom of which is surrounded by a folded wall. The depression is funnel-shaped, but compressed laterally, and along the anterior and posterior sloping wall a ridge passes downwards towards the bottom. The anterior ridge terminates in a freely projecting subconical clitoris, overhanging the urinary aperture, which is transversely extended and has soft plicated lips.

The clitoris is separated from the ridge by a transverse curved furrow. The posterior ridge is at its base more prominent, but gradually diminishes towards the bottom of

the pit; it terminates at the hinder margin of an irregularly rounded vaginal aperture, the lateral margins of which are folded in the usual way.

The mammary clefts are situated on either side of the hinder region of the vulva, and about 1½ in. from it. Each slit is about 1 in. in length, and is the opening of a pit 1 in. deep, from the bottom of which a small rounded nipple rises upwards. Above each mammary cleft, about 1 in. from it, is a shallow furrow parallel with it, marking out with it a slightly rounded area.

The anus, which lies a short distance behind the vulva, is 2 ft. 5 in. from the middle cleft of caudal fin.

The characteristic gular furrows extend from about 4 in. from anterior end of jaw for a distance of 4 ft. 8 in., terminating behind the level of the flipper. There are forty-five furrows between the two flippers, while further forward the number is increased, and at the angle of the mouth eight additional short furrows exist, on each side, dorsal of the longer ones. Each ridge which separates two furrows is ½ in. wide. These ridges are not produced by mere folding of the skin, but are delimited by straight grooves, ½ in. deep, into which the epidermis, of course, dips. But in transverse section of the skin it is evident that the blubber does not share in the folding, for its inner surface is plane, and consequently it is of less thickness below the furrows than below the ridges, where it measures 1¼ in. The middle series of furrows are rather shorter than the more laterally placed ones, whose length is given above; the ventral rugæ being 4 ft. 2½ in., and beginning 8½ in. from chin.

Measurements of External Features.

	Ft.	in.
Total length from tip of snout to end of fluke, measured over back	10	5
Length of body—*i.e.*, to notch in fluke..	10	1
" " (in straight line) ..	9	9½
Length of upper jaw, tip to angle of gape	1	10
" lower jaw	1	11
Tip of snout to anterior base of pectoral limb	3	2
" axilla	3	9
" base of dorsal fin	6	9
Length of base of dorsal fin	0	8
Height (greatest) of dorsal fin..	0	4
Distance from posterior margin of dorsal fin to tip of body—*i.e* median notch of fluke	2	
Distance of vulva from anterior end	7	
Greatest circumference of body, at a distance of 5 ft. 7 in. from snout		
Circumference at axilla	4	11½
" middle of dorsal fin (but, of course, excluding it)	3	6
" immediately anterior to root of fluke	1	6½

Weight, about 12 cwt. (estimated).

Measurements of Head.

	Ft.	in.
Gape	1	10
Tip of snout to anterior corner of eye	1	11
Eye—		
Length	0	1½
Height	0	0¾
Ear—		
Distance from posterior angle of eye	0	5
Length of auditory cleft	0	0¾
Nostrils (blowholes)—		
Tip of snout to anterior end	1	4
Length of nostril	0	3½
Distance between anterior ends	0	0¾
" posterior ends	0	2¾
Length of median internasal furrow	0	4½
Pectoral fin—		
Distance from snout	3	2
Breadth of base	0	7
Length along preaxial margin	1	8
" postaxial margin	1	3
Breadth (greatest)	0	5
Caudal fluke—		
Breadth (greatest) at end	2	4
Length, from root*	1	5
Length, behind end of body*	0	6½
Breadth of body at base of c.f.	0	3½

[After this article was set up I received from Sir William Turner his account of "The Lesser Rorqual in Scottish Seas," in Proc. R.S. Edin., 1892, xix., p. 36, in which he gives full details of external anatomy of several specimens. I regret that I cannot make use of the facts for comparison.]

ART. XIII.—*Notes on* Cogia breviceps, *the Lesser Sperm Whale.*

By W. B. BENHAM, D.Sc., M.A., F.Z.S., Professor of Biology, Otago University.

[*Read before the Otago Institute, 8th October, 1901.*]

ON the 30th August, 1900, I heard from Mr. Stronach, of Dunedin, that a small whale had been beached at Purakanui, and at once arranged to go down next day with the taxidermist, Mr. E. Jennings, to inspect it. On our arrival we ascertained that the whale had been driven ashore on the preceding Friday—just a week before. We obtained the services of Mr. Ewart, the fisherman living at the entrance of the bay, who rowed us across to the sandy spit that projects

* Measured three days after death. The sides had curved somewhat. The length is too great.

from the north side of the bay, and showed us the whale. We found the carcase just above high-water mark, nearly imbedded in sand, which had thus preserved the animal from decay, so that it appeared quite fresh. On removing the sand we discovered that the animal had been a good deal cut about—the head had been disarticulated from the vertebral column, and lay near at hand; the lower jaw, however, had been removed, and the top of the head had been injured by the removal of the little spermaceti contained there. The dorsal wall of the body had, likewise, been cut away for the blubber, and with it the dorsal fin. The tail-flukes were also missing, and the abdomen had been opened by a cut through the right sternal ribs, and the viscera lay outside the body.

Owing to the damage done I was unable to trace the true outlines of the body, or to locate the dorsal fin. This is the more to be regretted since specimens of this whale are rare; but fortunately Von Haast was able to give some further details of his specimen. Through the kind offices of Mr. Ewart I was, however, able to obtain the flukes from the Maori who had first discovered the whale, and who had cut away the blubber, &c.; and at a later period I obtained the lower jaw from a fisherman, who had retained and cleaned the bone as a "curio." Thus I obtained the entire skeleton—not a bone was missing.* The carcase was conveyed to Dunedin, together with some of the viscera—the stomach, larynx, generative organs—an account of which I have forwarded to the Zoological Society of London.†

The "short-headed sperm whale" has been described from our seas in the Transactions by Dr. Von Haast under the name of *Euphysetes pottsii*, but cetaceologists are now agreed that the various whales described as various species—*Euphysetes simus*, Owen, from India; *Euph. grayii*, Wall, and *Euph. macleayi*, Krefft, from the Australian seas; *K. floweri*, Gill, from the American coast of the North Pacific; and our New Zealand form—are all members of one and the same species—viz., *Kogia*‡ *breviceps*, originally described by De Blainville from a specimen from the Cape of Good Hope.

The various differences relied upon by these authors as of specific value are merely such as are due either to differences of sex or of age, or individual variations in the various specimens taken in various localities.

The specimen under consideration was a male, not quite

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* With the possible exception of the pelvic bone.

† See my papers—(1) "On the Larynx of certain Whales," P.Z.S., 1901, vol. i., p. 278; (2) "On the Anatomy of *Cogia breviceps*," 1901, vol. ii., p. 107.

‡ So spelt by Gray; but Flower, in his text-book on mammalia, spells it "Cogia."

fully grown, measuring 8 ft. 9 in. from tip of the snout to the bottom of the notch in the fluke; Von Haast's was a young female, the length of which was only 7 ft. 2 in.* I took no measurements of girth, as the animal was too much injured for such measurements to have any value.

The flipper, or pectoral limb, measured 14 in. in a straight line from base to tip, or 15 in. along the slightly curved anterior margin. Its breadth was 5½ in. across the widest part, and 5 in. across the base. The form of the flipper is shown in the figure. The anterior margin has a regular, slightly convex curve; the posterior margin is angulated, the angle being rounded, and enclosed by a shorter proximal limb of 4 in. and a longer distal concave limb of 8 in. in length.

The tail-flukes measured 2 ft. 3 in. across their ends; each fluke is 12 in. across (parallel to the axis of the body) in its widest part; the median notch between the two flukes is 5½ in. deep, measured from a line joining the two tips of the flukes.

The head measured 1 ft. 4 in.—in other words, is rather less than one-sixth the total length of the body, in which it is contained six and a half times.

One of the most interesting of the anatomical features is the asymmetry of the blowhole and of the structures related to "spouting." The single blowhole, or left nostril, lies on the upper surface of the head; is crescentic, with the convexity forwards and outwards, and therein differing from the usual form in *Odontocetes*. The distance between the horns of the crescent is 2½ in.; the inner (mesial) horn being rather further forward (1½ in.) than the outer one, and about 12 in. from the tip of the snout (measured after the blubber had been removed). Von Haast states that the "slit was 2 in. long, of which 1½ in. was on the left side and ½ in. on the right side." In my own specimen it appeared to be wholly on the left of the middle line.

Without going into details, which I have published elsewhere, I may briefly describe the apparatus connected with the blowhole. The crescent leads into a wide, shallow pit or vestibule, closed by a fleshy valve, on raising which the two nostrils are seen. The left one is a wide crescentic aperture leading into a wide circular and simple canal, which passes directly downwards through the skull to open into the naso-palatine canal which communicates with the mouth by the posterior nares. The right nostril is, however, very small and slit-like, situated at extreme right corner of the vestibule, and the canal into which it leads passes obliquely forwards and down-

* This is precisely the length given by Mr. Elliott, who supplied Professor Owen with the material on which his paper is founded. (See Trans. Zool. Soc., vi., p. 172.)

wards to open into a large chamber, 5 in. by 3 in. in diameter; thence a short canal passes into a second chamber of less dimensions, the hinder wall of which rests against the roof of the skull. The anterior wall is fleshy, and evidently capable of considerable movement in contraction and expansion. This lower chamber is somewhat pear-shaped, with the narrow end downwards, and thence a very narrow short canal opens into the naso-palatine canal.

Owing to the removal of the lower jaw I am unable to describe the form, size, or position of the mouth, which is described by other zoologists as small, and situated some distance from the tip of the snout. The lower jaw is provided on each side with thirteen conical, pointed, and slightly curved teeth; each tooth fits into a pit in the gum of the upper jaw. In the upper jaw are only two teeth, situated far forward, and carried by the premaxillary bones. On the right side the tooth projected from the gum for $\frac{3}{16}$ in., but the left tooth had only just "cut" the gum, so that only the extreme tip projected.

The alimentary canal had been torn out of the body, but the stomach was preserved and the intestines and contents examined. The length of the intestine is about 32 yards, of which the small intestine measured 30 yards; then it dilated to form a great sac a yard or so in length and 10 in. across, filled with dark-brown, almost black, fluid of considerable consistency, which consists of "sepia," or contents of the ink-sacs of the cuttlefishes upon which the whale had fed. The stomach contained great quantities of squid-beaks, lenses of squids' eyes, and pens of squids. Von Haast's suggestion that the whale feeds on "smaller hydroid zoophytes" is an error, due partly to the absence of beaks in the stomach of his specimen. Van Beneden and Gervais suggest, from the form of the teeth, that *Cogia* probably feeds on fishes (p. 354) rather than cuttles. I found no trace of fish.

The Skeleton.

As I have above indicated, I was able to obtain a complete skeleton.* There is one bone which, however, may have been present—the pelvic bone. But I carefully examined the region in which it should lie, and, moreover, removed and dissected the penis, of which an illustrated account appears in another journal.†

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* This skeleton has been purchased by the Cambridge University Zoological Museum; and an illustrated account of certain bones has been laid before the Zoological Society by me, and will be published in a forthcoming volume of the Proceedings of the Society.

† P.Z.S., 1901, vol. ii., p. 107.

Now, as is known, certain structures—the *corpora cavernosa* —are attached to the pelvis in mammals, and in some whales the bone is almost imbedded in this structure; but in *Cogia* I was unable to find it. On the other hand, Wall describes and figures the pelvis as consisting of four bones in a transverse row, an inner and outer, more or less quadrangular plates, on each side. I feel certain that no such bones existed in my specimen, for I looked specially for them. We may, I think, conclude that the pelvis is absent, and in this respect *Cogia* differs from the sperm whale.

The length of the vertebral column when the cleaned bones were set in position touching one another is 6 ft. 8 in., which, with the skull, measuring 1 ft. 3½ in., gives a total of 7 ft. 11½ in. for the axial skeleton. To this must be added several inches for the intravertebral discs. The epiphyses are separate.

The seven cervicals are in this genus entirely fused; and the usual evidences of the individual vertebræ, such as neural arches, spines, and transverse processes, are almost entirely obliterated. The atlas has its outlines distinct enough, and the neural arch and transverse process of the second vertebra are evident, while the seventh is also well marked out, but the intervening four vertebræ are so fused that it is practically impossible to distinguish their boundaries:—

CERVICAL VERTEBRAL MASS.

Greatest Length.	Greatest Height.	Centrum.			
		Height.		Breadth.	
		Anterior.	Posterior.	Anterior.	Posterior.
45 mm.	107 mm.	30 mm.	38 mm.	126 mm.	57 mm.

In this case the total length is measured along the ventral mid-line; the height, from the ventral mid-line to tip of the neural spine, which projects backwards from the hinder end of the mass, which is, really, the height of the 7th cervical vertebra. The anterior central breadth is across the facets from the occipital condyles.

This cervical mass is followed by forty-six free vertebræ, giving a total of fifty-three vertebræ, of which thirteen are thoracic, bearing ribs,* nine are lumbar, and twenty-three are caudal, of which the first thirteen bear chevrons. Von Haast's

* The 13th thoracic has on left side a small articular surface at the end of the transverse process, but on the right side this is absent.

specimen contained only fifty vertebræ, which are made up of seven cervical, twelve thoracic, eleven lumbar, and twenty caudal, with only eight chevrons. Wall's Australian specimen contains fifty-one vertebræ—seven cervical, fourteen thoracic, nine lumbar, and twenty-one caudal—with thirteen chevrons; Krefft's, fifty-five vertebræ—seven cervical, thirteen thoracic, nine lumbar, and twenty-six caudal—with ten chevrons. In Wall's specimen the 14th rib is represented in the figure as quite a small nodule, entirely unconnected with the vertebral column, and is only 1½ in. in length, in contrast to the 13th rib, measuring 11½ in. In Krefft's specimen, too, the last (13th) rib is much smaller (4 in.) than the 12th (12 in.) on the left side.

In addition to the twelve pairs of long ribs, the measurements of which are given below, I found amongst the *débris* of the macerating-pan, which had been carefully preserved by the taxidermist (Mr. Jennings, who took a very great deal of trouble to preserve every piece of bone and cartilage), a small bone, measuring 1½ in. in length (*i.e.*, 35 mm.) by about ⅜ in. (9 mm.) in greatest breadth: this appears to be a 13th rib of the left side. One end of this small bone is broader than the other, and appears to be the lower end. One surface of this bone is flat, the other strongly convex, and the general form agrees precisely with the shape of the 12th rib just below its curved region. Moreover, we found a long piece of cartilage, 4 in. long, broader at one end and pointed at the other, flattened and curved, which I believe to be the unossified distal portion of the rib. The proximal cartilage which may have connected this rib to the 13th thoracic vertebra is, unfortunately, missing; possibly the connection was ligamentous. We found no corresponding bone for the right side, but a short piece of cartilage, about 1 in. in length, corresponding to the upper end of the aforementioned cartilage, indicating the possible existence of a 13th rib on right side. There can be no doubt but that, except in a very carefully macerated skeleton, this last rib would be overlooked, and in skeletons found on shore there is little likelihood of its being preserved.

The figure given by Wall (who only found the ribs of right side and the 1st left rib) is wrong, in that he places this 14th rib in line with the lower end of the preceding one; it should be in line with the upper end, just where the curve commences to descend.

Van Beneden and Gervais, in the brief account (p. 515) given of an incomplete skeleton from Japan, find thirteen thoracic vertebræ, recognisable by articular facets for ribs, but add "there may have been fourteen pairs of ribs, the last being free."

MEASUREMENT OF VERTEBRÆ.

Vertebra.	Length.	Height.	Breadth.	Centrum. Transverse Diameter. Anterior Face.	Centrum. Transverse Diameter. Posterior Face.	Centrum. Vertical Diameter. Anterior Face.	Centrum. Vertical Diameter. Posterior Face.	Hypapophysis. Anterior Face.	Hypapophysis. Posterior Face.
	Mm.	Mm.	Mm.	Mm.	Mm.	Mm.	Mm.	Mm.	Mm.
Thoracic 1	25	87	106	43	47	38	..	..	..
„ 2	31	123	112	44	44	38	..	..	..
„ 3	35	135	111	42	43	39	..	..	..
„ 4	40	143	108	40	45	40	..	..	..
„ 5	40	149	106	42	44	38	..	..	..
„ 6	42	148	100	43	47	38	..	..	..
„ 7	44	150	105	43	46	38	41	..	..
„ 8	47	154	114	45	46	40	43	..	..
„ 9	50	157	130	47	49	42	..	..	..
„ 10	51	161	142	50	51	45	..	..	..
„ 11	53	165	157	50	53	44	47	..	..
„ 12	55	170	164	54	55	47	49	..	..
„ 13	56	172	182	54	55	48	50	..	2
Lumbar 1	57	183	181	57	..	48	52	..	13
„ 2	58	184	184	58	57	57	53	15	12
„ 3	59	189	185	59	57	53	..	19	20
„ 4	61	191	185	58	59	53	55	21	20
„ 5	60	192	183	59	57	54	56	21	21
„ 6	59	189	181	58	58	54	57	22	25
„ 7	59	182	177	59	58	55	57	25	25
„ 8	59	177	173	58	58	54	57	23	20
„ 9	59	163	165	60	60	56	56	20	17
Caudal 1	58	145	154	60	..	55	58	12	..
„ 2	57	122	145	60	..	57	58	..	..
„ 3	55	112	128	58	..	56	57	..	..
„ 4	53	102	108	57	..	55	..	..	..
„ 5	50	96	92	56	55	54	53	..	..
„ 6	48	92	80	55	54	52	53	..	..
„ 7	46	84	70	54	51	52	50	..	..
„ 8	44	73	58	52	49	50	49	..	..
„ 9	41	70	54	50	49	49	46	..	..
„ 10	40	65	50	50	45	49	45	..	..
„ 11	37	57	42	46	45	45	46	..	..
„ 12	32	50	38	43	41	43	41	..	..
„ 13	26	40	41	40	36	35	36	..	..
„ 14	21	33	36	32	26	30	29	..	..
„ 15	19	29	34	30	24	26	20	..	..
„ 16	18	24	32	26	22	23	18	..	..
„ 17	16	24	31	24	20	20	16	..	..
„ 18	14	20	27	21	22	18	18	..	..
„ 19	13	18	25	..	..	..	..	..	..
„ 20	13	15	22	..	..	..	..	..	..
„ 21	12	11	19	..	..	..	..	..	..
„ 22	12	11	15	..	..	..	..	..	..
„ 23	10	8	11	..	..	..	..	..	..

The foregoing table gives the principal measurements of the vertebræ: these are in millimeters, and taken with calipers. The length of the vertebra is the length of centrum measured from the centres of the epiphyses. The height is the greatest distance from the ventral surface of the centrum to tip of the neural spine. The breadth is taken from tip to tip of the tranverse processes where they exist, or across the widest part of centrum where the transverse processes are absent. The diameters of the centrum, or body of the vertebræ, are taken at the anterior and posterior extremities of the body itself.

It will be noted that the bodies of the vertebræ increase in size up to the middle of the lumbar series, and then decrease. This increase is quite gradual, but in the case of the decrease in height there is a sudden drop at the end of the lumbar series, owing to the sudden diminution of the neural spine. The bodies of the vertebræ are much larger in the middle of the vertebral column, the greater number of caudals having larger centres than the thoracics, which are relatively slender.

The hinder caudals, as in other whales, are incompletely formed—*i.e.*, the neural arch is imperfectly closed above; the 11th caudal has no neural spine, though the right and left neural laminæ meet, but in the 12th they do not meet, and by the 14th they are practically non-existent, so that the 15th *et seq.* consist of centrum only. The lumbar vertebræ exhibit a peculiarity, which appears to be characteristic, in the presence of the anterior and posterior prominences on the ventral surface of the centra, in the mid-line.

I have not thought it necessary to reproduce my detailed notes as to the form of the individual vertebræ. They are, on the whole, closely similar to those of the sperm whale (*Physeter macrocephalus*) as described by Flower; while the general appearance of the entire skeleton has been figured—more or less imperfectly, it is true—by Owen, Wall, Van Beneden and Gervais, and Von Haast.

The Chevrons.—The usual form of these bones is Y-shaped —*i.e.*, each consists of a right and left lamina meeting at an acute angle, and the fused plate so formed is produced downwards to form a keel. But there are variations of this type. The 1st chevron is U-shaped, each lamina having an outer face which is very convex; and, further, they only meet over a comparatively short area, so that there is no keel. The 7th, again, is V-shaped, the keel being practically absent; while the 12th is a short half-cylinder of bone with a shallow groove on its upper surface. It will be noticed that the 3rd chevron is the largest of the series.

CHEVRON BONES.

—	Vertical Diameter (Height).	Antero-posterior Diameter (Length).	Transverse Diameter (Breadth).
	Mm.	Mm.	Mm.
1st	39	28	30
2nd	61	26	35
3rd	70	33	36
4th	65	29	35
5th	57	27	37
6th	50	26	34
7th	41	25	32
8th	32	25	29
9th	28	25	28
10th	24	23	26
11th	20	21	24
12th	17	17	22
13th	10	12	20

The Ribs.—Of the thirteen ribs four are connected to the sternum by sternal ribs. The first vertebral rib, as in other cases, is much stouter and shorter than the following. It is broad, compressed antero-posteriorly and expanded distally. It has a distinctly marked "angle" near the proximal extremity, below which it curves suddenly downwards and inwards to meet its sternal rib. The proximal extremity bears distinct capitulum and tuberculum, as Von Haast noted, and herein our New Zealand specimens appear to differ from Wall's specimen; while in *Physeter*, which is its nearest ally, Flower states that these are not separate and distinct.

The two articular facets are nearly of equal size, though the capitulum is slightly the smaller. They are separated by a small "neck" measuring 14 mm. in length. This capitulum articulates with a conspicuous facet at the side of the hinder end of the cervical mass—*i.e.*, of the 7th cervical vertebra. The tuberculum, of course, articulates with the transverse process of the first thoracic.

The 2nd rib is much longer, but less stout; it is flattened and broad, however, like the first.

The capitulum and tuberculum are separated by a distance of 20 mm., the former being rather the larger facet of the two. The angle is well marked, but less acute than in the first rib, and the curvature is more gradual.

In this and the following four ribs the capitulum articulates with the posterior end of the preceding vertebra only, and not with its own vertebra.

The 3rd to 6th ribs are practically similar, but the curvature is different, for in the first place the angle is less

marked in all the ribs following the 2nd, and the curvature is more gentle and regular. The upper region, instead of being horizontal, is inclined downwards, and this general form is retained by the rest; but the convexity of the curve decreases, so that the ribs, as traced backwards, tend to become straighter.

In the 7th and following ribs the capitulum ceases to articulate with any vertebra; it is bluntly pointed, and probably connected by ligament to the column.

The 13th rib has been described.

There is no important difference between the ribs of the right and left sides. I add a table of measurements. The length of the rib is measured in a straight line from the inner margin of its articular extremity to the inner margin of the distal extremity. The "curvature" is really the distance of the most remote point on the inner margin from the line joining the two extremities of the ribs.

Ribs.	Length.	Curvature.
	Mm.	Mm.
1st	168	72
2nd	277	100
3rd	330	115
4th	352	115
5th	355	115
6th	353	105
7th	365	93
8th	343	73
9th	312	61
10th	285	55
11th	260	46
12th	215	33
13th	35*	..

The *sternum* has not, as far as I am aware, received a detailed description by any previous author, for it was only partially recovered for Wall's specimen, and Von Haast makes no mention of it. In the present specimen it and the sternal ribs are complete. It consists of three sternebræ, the first and second formed of a single bone, the last of a pair of small bones imbedded in cartilage. There are four pairs of sternal ribs, measuring respectively 90 mm., 75 mm., 60 mm., and 30 mm.

The total length of sternum, including the cartilage at each extremity, is 260 mm.; the greatest breadth, measured just behind the articulation of the first sternal rib, is 155 mm.;

* Together with cartilage above and below.

and the least breadth, measured across last sternebra, is 45 mm.

The cartilage of this and other parts of the skeleton has been treated by the glycerine-gelatine method, and retains its true form and relations; but, since the cartilage is not likely to be present in all skeletons, I give the measurements of the bony parts as well:—

	Mm.
First bony sternebra—	
Length (lower surface)	90
Breadth (anterior end)	100
Breadth (posterior end)...	60
Thickness (dorso-ventral) in middle	10
Second bony sternebra—	
Length	76
Breadth (anterior end)	54
Breadth (middle)	43
Breadth (posterior end)...	51
Thickness	12
Third bony sternebra—	
Right ossicle—Length	31
Breadth	20
Left ossicle—Length	32
Breadth	20
Thickness	13

The anterior end of the sternum is slightly bent upwards, but otherwise the bones are flat, with rounded lateral margins. The 1st sternebra is thinner at anterior than at posterior end. The thickness increases from the anterior end of sternum (where it is 8 mm.) to hinder end (13 mm.). The margin of the last sternebra—or, rather, of each of the two constituent ossicles—is not rounded, but slopes away from the dorsal surface outwards and downwards, so that the lower surface is wider than the upper (43 mm.).

The *hyoid bone* is very briefly referred to by Wall, and is rather more fully described by Van Beneden and Gervais, who figure it. In the Purakanui specimen it was complete, the bones and cartilages being uninjured.

The basi-hyal is a flat irregularly semicircular bone, at the anterior margin of which is a pair of cartilages, which evidently correspond to the bony apex of the basi-hyal of *Physeter*, but which in *Cogia* do not appear to ossify. The thyro-hyal bones are circular discs imbedded in a large cartilaginous plate.

The anterior cornu consists of two segments, a proximal short, curved, subcylindrical cartilage (cerato-hyal) and a longer distal region, in the middle of which is a cylindrical bone (the stylo-hyal).

The two anterior cornua arise close to one another from the cartilages referred to as joining the anterior end of the basi-hyal.

Basi-hyal: Greatest breadth, 84 mm.; greatest length, 66 mm.; thickness, 5 mm.; length of cartilaginous cap, 18 mm.; breadth, 20 mm.; length of ossification in thyro-hyal, 55 mm.; breadth, 46 mm.; length of each half of basi- and thyro-hyal from anterior end of cap to posterior end of cornu, 156 mm.; greatest width across external margins of posterior cornua, 188 mm.

Anterior cornu: Total length, 220 mm.; cerato-hyal cartilage (along middle line), 37 mm.; stylo-hyal, 175 mm.; length of bone (along middle line), 65 mm.; thickness, 15 mm.; greatest length along hinder margin, 75 mm.

Skeleton of Fore Limb.—This has been but indistinctly figured by Von Haast, whose specimen was imperfect, and by Wall, but more accurately by Krefft. The scapula is a nearly equilateral triangle, the upper border being curved. The greater part of the outer surface (post-axial fossa) is feebly concave. The inner surface is nearly flat, but as the anterior border is slightly everted so as to form a low rounded but depressed ridge, extending nearly across the bone, and as the superior border is also somewhat everted, the inner face is slightly convex.

The spine is but feebly developed, but the acromion is a large compressed squarish process, obliquely truncated distally. It bears on its upper margin a shorter process.

The coracoid process is large and well marked, nearly as long as the acromion, but narrower. The glenoid cup is oval.

Measurements of Scapula, in Millimetres.

Greatest height (measured from highest point of superior border to anterior margin of glenoid facet) ...	164
Length of posterior border	107
Length of anterior border	159
From antero-posterior angle to origin of acromion ...	76
Breadth, greatest (from anterior to posterior angle of superior border)	184
Breadth immediately above acromion	83
Breadth from posterior margin of glenoid to tip of acromion...	101
Acromion: Length	48
Acromion: Vertical height, near root	35
From posterior margin of glenoid to end of coracoid ...	84
From anterior margin of glenoid to end of coracoid ...	47
Coracoid: Height at root	22
Glenoid facet: Length	46
Glenoid facet: Width	31

The *humerus* is provided with a small deltoid crest 15 mm. long and 5 mm. in height. The head and tubercle are firmly united to the end of the shaft, as is also the distal epiphysis; but the epiphyses of the radius and ulna are not as yet united to these bones. Each of these epiphyses is still imbedded in a great mass of cartilage and is invisible in the preserved specimen; the bone can, however, be felt by probing the cartilage with a needle. The proximal epiphysial cartilage of the ulna is prolonged downwards to form a spur on the post-axial side of the limb, which in *Physeter* is represented by a bony olecranon. Possibly this becomes ossified in a fully matured animal, though it is not shown in Von Haast's drawings; but the photograph accompanying the second edition of Wall's paper and the woodcut in Krefft's just indicate a small process here.

The *carpal bones* are five in number, three in the proximal row and two in the distal. Each is an irregular circular disc of bone imbedded in cartilage, with vertical sides. The pisiform is cartilaginous. There is, too, a curious prolongation of the distal epiphysial cartilage of the radius, which extends outside the pre-axial carpal and touches the 1st metacarpal.

In the *fingers* each phalanx is provided with its own epiphysial cartilage, but with no bony epiphysis, and the neighbouring cartilages are distinct, not fused as in *Mystacocetes*. The metacarpals are short, not much longer than the phalanges.

The 1st digit consists of a rounded metacarpal resembling a carpal. This is followed by a long phalanx and a shorter one. In the 2nd the metacarpal is broader than that of the other digits, but not so long as in the 3rd. This is followed by ten phalanges, of which the terminal is very small, and the three sub-terminals are circular. The 3rd has seven phalanges, the 4th six phalanges, and the 5th three phalanges, which are all nearly circular, as are the terminals of the other digits. On the left hand the 1st has two phalanges, rather larger than in the right; the 2nd has nine, the 3rd seven, the 4th six, and the 5th two only.

The lengths of the digits in ascending order are—I. shortest, V., IV., III., II. The following are the lengths of the digits: Right hand—The 1st measures 55 mm. along pre-axial border, and including cartilage; 2nd, 183 mm.; 3rd, 148 mm.; 4th, 102 mm.; 5th, 68 mm. The terminal cartilages are missing in the 2nd, 3rd, 4th, and 5th digits. Left hand—The 1st measures 52 mm.; 2nd, 185 mm.; 3rd, 158 mm.; 4th, 114 mm.; 5th, 52 mm.

The total length of limb from head of humerus to tip of 2nd digit is 372 mm.

Humerus: Length (including cartilage), 95 mm.; bone only, 65 mm. Transverse diameter of bone—Upper end, 45 mm.; lower end, 50 mm. Thickness, 24 mm.

Radius: Length along pre-axial side, 75 mm.; post-axial, 60 mm. Length of bone only (along its middle), 60 mm. Least breadth (along its middle), 30 mm. Thickness, 12 mm.

Ulna: Total length along post-axial, 63 mm.; pre-axial, 60 mm. Total length bone (in middle), 55 mm. Least breadth, 26 mm. Thickness, 10 mm. Olecranon, 25 mm.

Total breadth at distal end of R.U. (including cartilage), 80 mm.

In the 2nd edition of Wall's paper a photograph of the right limb is given, which appears to agree well with the limb of the present specimen, although the bones of the former had to be pieced together, and were not found *in situ,* so that the cartilaginous parts do not exhibit that characteristic feature above referred to. Wall describes "seven" carpal bones, but it is pretty evident that the "two linear transverse bones" are the distal epiphyses of the radius and ulna, at the ends of which he locates them. The remaining five are accurately shown in the photograph and described in the text. It is a more accurate representation of affairs than the woodcut illustrating Krefft's paper. The figure also seems to show the peculiar prolongation of the cartilage from the radial epiphysis towards the metacarpal of the first digit. The pisiform, however, is not shown.

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Art. XIV.—*On a Small Collection of* Diptera *from the Southern Islands of New Zealand.*

By Captain F. W. Hutton, F.R.S.

[*Read before the Philosophical Institute of Canterbury, 3rd July, 1901.*]

This collection was made by myself last January, when, at the invitation of His Excellency the Earl of Ranfurly, I visited the islands in the Government steamer "Hinemoa." The time for collecting was short. I landed once on the Snares, five times on Auckland Islands, once on Campbell Island, and once on Antipodes Island. From what I saw I am convinced that there are many more species to be obtained. I saw spiders on all the islands, and a millepede on Auckland Islands; but, unfortunately, my foot slipped just as I was going to put it in a bottle and I could not find it again. The common house-fly (*Musca domestica*) was common on the steamer, but I did not find it on any of the islands. This may be due to the fact of there being no horses on the islands. Also, *Calliphora quadrimaculata* came freely on board while we were lying at the Auckland Islands, but all left before we got to Campbell Island, only a few hours' steaming, and I did not find the species there at all. These facts show that flies are not so easily spread by steamers as is commonly supposed.

Simulium vexans.

S. vexans, Mik, Verh. d. zool.-bot. Gesell. in Wien, vol. xxxi., p. 201 (1881).

"Fem.—Nigro-fuscum, polline cinerascenti obtectum, fronte thoracisque dorso orichalceo-pilosulis; halteribus pallidis, pedibus fuscis, geniculis metatarsique posticis pallidis. Alarum venis posterioribus sat crassis. Long. corp. 3 mm., long. alar. 3·3 mm." (Mik).

Hab. Auckland Islands. Not very abundant.

This species differs from *S. australiense* in being larger, in the absence of yellow spots from the shoulders, and in the femora and tibiæ being dark; also, the fifth and sixth longitudinal veins are stronger.

There are ten joints in the antennæ.

Beris micans.

B. micans, Hutton, Trans. N.Z. Inst., vol. xxxiii., p. 6 (1901).

Hab. The Snares.

A single specimen. The antennæ are very dark-brown.

Empis, sp. ind.

There is in the collection a specimen from the Auckland Islands belonging to this genus, but it is not in a sufficiently good state to allow of description.

Helophilus campbellicus, sp. nov.

Female.—Vertex blackish olivaceous, with black hairs; face, including a band above the antennæ, fulvous, shining. Antennæ black, the third joint fulvous margined with black. Proboscis black; a few white hairs on the cheeks. Thorax blackish olivaceous, with four broad grey bands and a median narrow grey line. Scutellum tawny, pale at the tip. Abdomen metallic bronzy-green, with a few scattered white hairs, especially at the sides and below. Legs fuscous; the tibiæ inside and the tarsi fulvous. Halteres fuscous, tipped with red. Alulæ white. Wings tinged with brown, the veins black, passing into brown at their insertions. Length, 11 mm.; wing, 10½ mm.

Hab. Campbell Island. A single specimen.

This species differs from *H. chathamensis* and from *H. latifrons* in the colour of the abdomen and in the white hairs with which it is partially clothed. In general appearance it closely resembles *Calliphora eudypti*, but I do not suppose that this is caused by mimicry.

Calliphora quadrimaculata.

Length, 10–11 mm.; wing, 9 mm.

Hab. Auckland Islands. Very common.

Calliphora icela.

Length, 8 mm.; wing, 7½ mm.

Hab. Auckland Islands. A single specimen.

Calliphora eudypti, sp. nov.

Frontal band of the head blackish-brown, the sides and cheeks brownish-yellow in some lights, brown in others, sometimes yellow, with a brown transverse band. Eyes bare. Antennæ with the first and second joints brown, the third black, sometimes rufous at the base. Proboscis black. Palpi orange or tawny. Thorax bluish-black, with hoary pollen, and three longitudinal black stripes. An oval orange spot on each side of the prothorax, and another on each side of the metathorax. Scutellum bluish-black. Abdomen metallic bronzy-green, with scattered black hairs. Legs tawny or rufous; the fore femora for nearly the whole length, the middle and hind tibiæ on the basal half, black. Halteres rufous-orange. Alulæ brownish, margined with fulvous. Wings colourless; the first posterior cell open, the apical transverse

vein only slightly curved backwards near the bend; posterior transverse vein slightly sinuated. Veins black, becoming bright-rufous at their insertions. Length, 8–10 mm.; wing, 7–8 mm.

Hab. Snares, Auckland Islands, and Campbell Island. Especially abundant at the penguin rookeries on the Snares. The Campbell Island specimens have the legs darker, and more black on the femora.

This and the following species are very different from those of New Zealand in the colour of the abdomen, and approach more to the species from Tasmania. Perhaps *C. tibialis* is the nearest ally of *C. eudypti;* but in that species the abdomen is tessellated with yellow on an olive ground, and the antennæ are fulvous.

Calliphora antipodea, sp. nov.

Head black, with a narrow white band on each side of the face below the insertion of the antennæ. Antennæ black. Thorax and scutellum blackish-blue. Abdomen metallic bronzy-green, with scattered black hairs. Legs black. Halteres rufous-orange. Wings colourless; like those of *C. eudypti*, except that the apical transverse vein is nearly straight. Length, 7½ mm.; wing, 7½ mm.

Hab. Antipodes Island.

This species, perhaps, comes nearest to *C. clausa*, of Australia; but there is no grey on the face, the third joint of the antennæ is black, there are no blue reflections on the abdomen, and the first posterior cell is not closed.

Tricophthicus villosus, sp. nov.

Vertex jet-black, face yellowish-white; antennæ and proboscis black. Third joint of the antennæ about one and a half times the length of the second; arista minutely pubescent. Eyes hairy. Palpi long and narrow. Head hairy. Thorax brownish-grey, with three obscure longitudinal black bands, generally broken; a number of short black hairs among the longer ones. Abdomen grey; the second to fourth segments with a pair of triangular black spots, the fifth segment with a central black line. Legs brown; the tibiæ lighter than the femora, which are almost black. Halteres fulvous. Alulæ brownish-white, margined with brown. Wings slightly tinged with brown; the veins dark-brown, almost black. Auxiliary vein distinct from the first longitudinal; the posterior cross-vein nearly straight. Length, 9 mm.; wing, 8 mm.

Hab. Auckland Islands.

This species differs from *T. dolosus* in being darker in

colour and more hairy. The abdomen of the male is especially hairy.

Homalomyia fraxinea, Hutton.

Hab. Auckland Islands and the Antipodes.

Homalomyia fuliginosa, Hutton.

Hab. The Snares.

Limnophora aucklandica, sp. nov.

Eyes wide apart; vertex dark-brown, face yellow. Antennæ dark-brown, the third joint about one and a half times the length of the second; arista pubescent. Eyes naked. Ocellar and vertical cephalic bristles. Thorax reddish-brown, with three obscure black lines. Abdomen brown, with grey spots on each side of the segments. Legs dark-brown; the tibiæ testaceous, the femora with grey pollen. Halteres fulvous. Alulæ white, unequal. Wings without spots; the veins black, passing into fulvous at the insertions. Distance between the cross-veins about one and a half times the length of the posterior cross-vein. The sixth and seventh longitudinals well marked, the seventh rather the longer. Length, 7 mm.; wing, 7 mm.

Hab. Auckland Islands.

Cœlopa littoralis, Hutton.

Legs rather lighter in colour than in New Zealand specimens.

Hab. Auckland Islands and Campbell Island.

In this species and the next there are no oral vibrissæ, and perhaps they would be better placed in *Actora.* But there are no costal bristles either.

Cœlopa curvipes, sp. nov.

Vertex reddish-brown, the ocellar triangle and sides of the face grey; a spot between the antennæ rufous, dusted with grey. Antennæ piceous, the arista pubescent. Proboscis and palpi piceous. Thorax and abdomen brown, the former dusted with grey, especially on the sides. Legs fulvous; the tibiæ clouded with fuscous, but very variable. Hind legs elongated, the tibiæ much curved inwards. Halteres pale-brown. Wings colourless, unspotted, the veins brown; no bristles on the costa. Chief cross-vein short; the first posterior cell broadest opposite to the posterior cross-vein. Length, ♂ 4½ mm., ♀ 5½–6½ mm.; wing, ♂ 4 mm., ♀ 7 mm.

Hab. Auckland Island. On the sea-shore.

Easily distinguished by its elongated and curved hind legs.

Cœlopa rufa, sp. nov.

Vertex dark-brown; the face and two first joints of the antennæ fulvous. Proboscis and palpi piceous. Thorax and abdomen brown, dusted with grey. Legs fulvous, the femora fuscous in the middle for the greater part of their length. Wings colourless; the veins brown, passing into fulvous at their insertions. Length, ♀ 5 mm.; wing, 5 mm.

Hab. The Snares.

Heteromyza laquei, sp. nov.

Fulvous, paler below than above; the thorax with several narrow dark lines; abdomen brown above. Front broad. Antennæ testaceous, the third joint nearly round, considerably longer than the second; arista bare. Oral vibrissæ present, but no bristles on the face. Three bristles in the median dorsal row of the mesonotum, not including those of the scutellum. Middle tibiæ with strong spurs, all of them with a subapical bristle. Wings pale-tawny, the costal border without any long bristles. Distance between the cross-veins about one and three-quarter times the length of the posterior cross-vein. Length, 5 mm.; wings, 5 mm.

Hab. The Snares.

This species is in appearance much like the New Zealand species of *Leria*, but there are no bristles on the costa.

Lauxania carbonaria, sp. nov.

Entirely black except the eyes, which are red; the abdomen with greenish submetallic reflections. Apices of the tibiæ and tarsi pale-brown. Third joint of the antennæ linear, its length about three times its breadth; the arista bare. There are two pairs of fronto-orbital bristles, none on the front; and no oral vibrissæ. Tibiæ with a preapical bristle Wings yellowish, the veins fulvous. Distance between the cross-veins about one a half times the length of the posterior cross-vein, which is three-quarters of its own length from the margin. Length, 3½ mm.; wing, 4 mm.

Hab. Auckland Islands.

Lonchæa aucklandica, sp. nov.

Front broad, blackish-grey, four fronto-orbital bristles in a row. Face with bristles, one pair of which, near the mouth, are longer than the others. Eyes red. Palpi fulvous. Antennæ short; the third joint oval, truncated, its length less than twice its breadth; the arista bare. Thorax and abdomen black. Femora black, the tibiæ and tarsi brown. No preapical bristle. Halteres fulvous. Wings nearly colourless; the veins black, getting brown near the insertion. Distance between the cross-veins one and a half times the length

of the posterior cross-vein, which is about three-quarters of its own length from the margin. Length, 3½ mm.; wing, 3 mm.

Hab. Auckland Islands.

Milichia littorea, sp. nov.

Brown; sides of the face, ocellar triangle, and four stripes on the thorax darker. Eyes round. Antennæ and palpi piceous; third joint of the antennæ round; the arista bare. Mouth large, oval, the anterior margin thin and sharp, with a pair of small vibrissæ. Legs and lower surface dark-brown, dusted with grey. Abdomen short. Mesonotum with bristles in the middle, four in a row. Halteres fulvous. Wings fuscous, with pale spots, three in the submarginal cell, two in the first posterior cell, one in the second posterior, and one in the discal cell. The costal, exterior part of marginal, and first basal cells are clear. There are three distinct basal cells. Veins very dark-brown. No incision on the costa before the tip of the first longitudinal vein. Posterior cross-vein present, situated nearly in the middle of the wing; not much more than its own length from the margin. The distance between the cross-veins is quite twice the length of the posterior cross-vein. Length, 3½ mm.; wing, 4½ mm.

Hab. Antipodes Island. On pools between tide-marks.

Ochthiphila australis, sp. nov.

Black, the eyes reddish. Halteres white. Abdomen narrow. Front with long bristles. No oral vibrissæ, but a row of bristles on each side of the mouth. Mesonotum with two rows of five bristles each in the middle. Wings fuscous; basal cells small but distinct. Distance between the cross-veins about twice the length of the posterior cross-vein, which is situated rather more than its own length from the margin. Length, 2 mm.; wing, 3 mm.

Hab. Campbell Island.

Drosophila enderbii, sp. nov.

Blackish-brown, the face with yellowish tomentum. A little grey tomentum on the lower surface and the legs. A row of bristles on each side of the face, but none on the mouth. Arista with a row of six bristles. Wings clear, the veins black. Only one basal cell. Distance between the cross-veins about three times the length of the posterior cross-vein, which is situated at about its own length from the margin. Length, 2 mm.; wing, 2 mm.

Hab. Enderby Island, Auckland group.

Smaller and darker than any of the described New Zealand species.

Asteia levis, sp. nov.

Head fulvous, the eyes black. Antennæ short, the third joint round; arista slender, bare. Front broad. Thorax and abdomen brown above, pale-fulvous below. Legs pale-fulvous. Wings slightly tinged with yellow, the veins fulvous. No posterior cross-vein. Second longitudinal short, nearly attaining to half the length of the wing. Length, 3 mm.; wing, 3½ mm.

Hab. Stewart Island.

This species differs from *A. amœna* in having no hairs on the arista, and in the second longitudinal vein being longer.

ART. XV.—*The Beetles of the Auckland Islands.*

By Captain F. W. HUTTON, F.R.S., *with Descriptions of New Species* by Captain T. BROUN, F.E.S.

[*Read before the Philosophical Institute of Canterbury, 6th November, 1901.*]

LAST January, at the invitation of His Excellency the Earl of Ranfurly, I visited the southern islands of New Zealand in the Government s.s. "Hinemoa," commanded by Captain Bollans. The chief object of our visit, in addition to examining the provision depots, was to make a collection of birds for the British Museum. But, as I had nothing to do with the collection of the specimens, I devoted all the time I could to the *Diptera*. No systematic attempt was made to collect *Coleoptera*, and only five specimens were obtained. These were all new to science, and belong to four new species and one new genus. This is a very good proof that a great deal remains to be done in collecting insects in these islands. Indeed, it is remarkable that after the visits of four scientific expeditions to the Auckland group—two French, one English, and one German—so very little should be known about the insects.

Lyperobius læviusculus was captured on the high land of Adam's Island, when the party were going to the albatros nesting-ground. They were feeding, I believe, on *Ligusticum antipodum*. *Inocatoptes incertus* was obtained on the high land at the head of Port Ross, but I do not know on what plant it was feeding. Both specimens of *Euthenarus* were found under stones in Carnley Harbour, near where the "Grafton" was wrecked.

I also saw on the islands, several times, a moth which appeared to be a *Crambus*, of which I did not take specimens;

also a Myriapod, belonging to the *Polydesmidæ*, which I failed to secure. On Antipodes Island the magpie moth (*Nyctemera annulata*) is common. I also saw spiders on all the islands, but as my bottles were full of *Diptera* I could not collect them.

The following is a list of the beetles at present known from the Auckland Islands:—

Family Carabidæ.

Calathus rubromarginatus, Blanchard.
Euthenarus cilicollis, Broun.
Euthenarus huttoni, Broun.
Heterodactylus nebrioides, Guerin.
Heterodactylus castaneus, Blanchard.
Pristanclus brevis, Blanchard.
Oopterus clivinoides, Guerin.
Oopterus plicaticollis, Blanchard.

Family Tenebrionidæ.

Adelium tuberculatum, Guerin.

Family Curculionidæ.

Inocatoptes incertus, Broun.
Lyperobius læviusculus, Broun.

Of these all the species and the genera *Heterodactylus*, *Pristanclus*, and *Inocatoptes* are endemic. *Oopterus* and *Lyperobius* are confined to New Zealand and the Auckland Islands. *Adelium* extends to New Zealand, Australia, Tasmania, New Caledonia, and Chili. *Calathus* is a northern (Holarctic) genus extending as far south as India and Mexico. There is only one species in New Zealand, *C. zealandicus*, Redtenbacher, having been erroneously referred to this country (see "Zoological Record, 1891," Insects, p. 89). It is, however, doubtful whether our southern species really belong to *Calathus*.

Descriptions by Captain T. Broun, F.E.S.

Group HARPALIDÆ.

Euthenarus (?) cilicollis, sp. nov.

Body fusco-piceous; elytra with a testaceous streak along the outer posterior margin of each; tibiæ and antennæ red, palpi paler. *Head* rather short, somewhat uneven. *Labrum* truncate. *Eyes* prominent. *Thorax* one-third broader than long, its base truncate and minutely ciliate; the sides rounded, widest just before the middle, much narrowed

behind; posterior angles rectangular but not projecting, the anterior slightly prominent but obtuse; disc a little convex, the longitudinal dorsal groove feebly impressed, the simple basal fossæ rather shallow and almost united by a curved transversal impression which is enlarged at the middle; there are some slight linear impressions across the surface. *Elytra* quite oval, slightly convex, not sinuate posteriorly; humeral angles obsolete; with simple regular striæ; interstices impunctate. Anterior *tibiæ* slightly thickened and ciliate at the extremity. *Tarsi* with brush-like soles, joints 2–4, of the front pair only, dilated and cordiform; the basal articulation longer, slender at base but broad at apex; the fourth joint deeply emarginate and with its inner angle somewhat prolonged; the posterior tarsi elongate, their fourth joint excavate above and prolonged underneath, without definite angles but longer externally, and ciliate below. *Antennæ* reaching backwards to the shoulders, their seven terminal joints pubescent; the first is as elongate as the fourth but stouter, the second is one-third shorter than the following one. ♂. Length, 5¼ lines; breadth, 2⅜ lines.

Auckland Islands. One mutilated individual has been placed at my disposal by Captain Hutton.

Obs. It was at first intended that this and the following species should be placed with Blanchard's *Calathus rubromarginatus*, but after studying the structure of the tarsi it became apparent that the present species should not be located in the group *Anchomenidæ*. Although Blanchard's species is unknown to me except by description, I have little hesitation in uniting it with those now described as exponents of one genus; but I am not prepared to make a new generic name for them until more specimens can be got for dissection. Under these circumstances, they are placed temporarily with *Euthenarus* in the group *Harpalidæ*.

E. huttoni, sp. nov.

Body rufo-piceous, slightly nitid; legs pitchy-red, antennæ and palpi paler. *Head* finely rugose, not short. *Thorax* about as long as broad, widest near the middle, only moderately rounded there; anterior angles slightly prominent, the basal rectangular, and, owing to the large and deep fossæ, appearing as if slightly elevated; the median dorsal groove is distinct. *Scutellum* short. *Elytra* oblong-oval, rather broad, with fine, regular, impunctate striæ; interstices simple. ♂. Length, 5 lines; breadth, 2⅛ lines.

Auckland Islands. One specimen only, preserved in the Canterbury Museum. This species has been named in honour of its discoverer.

In this species the eyes are less prominent and more dis-

tant from the thoracic margin than in *E. cilicollis*. The thorax is rather longer, and differs in form; its sides are quite obviously marginated, and the basal foveæ are large and deeply impressed. The elytra also differ in contour, owing chiefly to being much less narrowed towards the shoulders.

Group OTIORHYNCHIDÆ.

INOCATOPTES, gen. nov.

Rostrum moderately short and broad. *Scrobe* well defined near the apex, but becoming shallow behind. *Eyes* moderately prominent, distinctly facetted, subtruncate in front. *Prosternum* incurved. *Mesosternum* with a raised lamina between the coxæ. *Abdomen* finely setose; basal segment medially emarginate, third and fourth short.

This should be located between *Inophlœus* and *Catoptes*. From the latter it differs in the shape of the eyes, in the direction of the scrobes, and in the less-developed ocular lobes. From the former it may be at once distinguished by the absence of the double series of ciliæ at the extremity of the posterior tibiæ, by the distinct intercoxal process, and by the absence of the usual nodosities and acuminate apices of the elytra.

Inocatoptes incertus, sp. nov.

Subovate, without nodiform elevations, thinly clothed with decumbent yellowish setæ. *Rostrum* rather flat, with a fine longitudinal carina, terminating in a fovea between the eyes. *Scape* clavate at extremity, extending to back part of the eye. *Funiculus* sparsely setose; basal two joints almost equally elongate, third slightly longer than fourth. *Club* finely pubescent, elongate-oval, its three joints of nearly equal length. *Thorax* transverse, base and apex truncate; uneven above, but without distinct sculpture. *Scutellum* distinct. *Elytra* oviform, a little broader at the base than the thorax; each elytron with six discoidal series of moderate punctures, the external two coarser; the four nearest the suture form fine striæ. *Legs* elongate, femora incrassate near the middle; tibiæ setose, the front pair slightly arcuate externally, somewhat thickened and produced at the inner apices. *Tarsi* normal. Length (rost. included), 8 lines; breadth, 3½ lines.

Colouration has not been alluded to because the only specimen extant is somewhat immature, and, although it is rufo-castaneous, it may become dark or greyish. The deciduous supplementary mandibles are conspicuous.

Described from one example in the Canterbury Museum. It was found on the main island, Auckland group, by the Hon. H. C. Butler. Type in the Canterbury Museum.

Group MOLYTIDÆ.

Lyperobius læviusculus, sp. nov.

Pitchy-black, sometimes rufo-piceous; hind-body sparingly clothed with depressed, testaceous, setiform scales. *Rostrum* nearly plane above, medially narrowed, rather finely punctured. *Head* broader than the rostrum, with a shallow median groove before the eyes and some transversal linear impressions behind. *Eyes* more rotundate than those of the typical species. *Scrobes* deep in front, but quite indefinite behind. *Scape* thickened apically, attaining the back of the eye. *Funiculus* sparsely pilose, second joint only slightly shorter than the first; joints 3–7 moniliform. *Club* triarticulate, rather elongate, finely pubescent. *Thorax* somewhat uneven, without central carina, finely punctate. *Elytra* oblong-oval, humeral angles narrowed and rounded, rather acuminate posteriorly; each elytron indistinctly tricostate, suture slightly elevated, interstices nearly smooth, with only feebly impressed series of punctures. *Legs* rather elongate; femora clavate; tibiæ flexuous, without the usual inner armature just above the extremity; the anterior pair with pale erect setæ along the inside. *Underside* nearly smooth, almost nude. *Prosternum* a little emarginate. Length (rost. included), 10–12 lines; breadth, 3½–5 lines.

Auckland Islands. Captain Bollans, of the Government steamer "Hinemoa," found two specimens on Adam's Island. The larger one has very indefinite elytral costæ. One specimen retained in Captain Broun's collection, the other placed in the Canterbury Museum.

ART. XVI.—*Additions to the* Diptera *Fauna of New Zealand.*

By Captain F. W. HUTTON, F.R.S.

[*Read before the Philosophical Institute of Canterbury, 6th November, 1901.*]

Family PSYCHODIDÆ.

Genus PSYCHODA, Latreille, 1796.

Wings pointed; two simple veins between the forked veins, the second of these two ending at or before the apex. Proboscis compressed, the maxillæ nearly as long.

Psychoda phalænoides, Linnæus.

Dark-brown, with pale-grey hairs on the head and abdomen and brown hairs on the mesonotum. Antennæ

with black bands. Wings without spots, pellucid, with pale-grey hairs on the veins; veins brownish. Halteres white. Legs dark-brown, with pale-grey hairs. Length, $1\frac{1}{2}$ mm.; wing, 2 mm.

Hab. Christchurch (F. W. H.), common; Auckland (Suter).

Introduced from Europe.

Genus PERICOMA, Walker, 1856.

Wings pointed or rounded; two simple veins between the forked veins, the second of these two ending distinctly behind the tip of the wing. Proboscis with broad liplets.

Pericoma funebris, sp. nov.

Head and thorax very dark-brown; thorax nearly bare, but some white hairs at the root of the wing. Abdomen paler brown, covered with reddish-brown hairs. Legs brown, with some white hairs near the tips of the tibiæ. Wings broad, rounded at the apex, densely covered with dark-brown hairs, passing into reddish-brown a little below the tip. No spots. The fork of the second longitudinal vein lies rather inside that of the fourth longitudinal. The anterior of the two simple veins reaches the margin a little before the apex of the wing, while the second one is distinctly behind it. Length, $3\frac{1}{2}$ mm.; wing, 4 mm.

Hab. Wellington (G. V. Hudson).

Pericoma variegata, sp. nov.

Head and anterior portion of thorax velvety black, the posterior portion foxy-red. Abdomen brown. Legs brown, the tarsi blackish. Wings broad and rounded at the tip. Dark-brown, with spots and streaks of foxy-red and some white hairs sprinkled through the brown ones. Neuration as in the last species. Length, 4 mm.; wing, $5\frac{1}{4}$ mm.

Hab. Wellington (G. V. Hudson).

Family CHIRONOMIDÆ.

KEY TO THE GENERA.

Only one basal cell.
- **Wings bare.**
  - **Front metatarsi longer than the tibiæ** .. *Chironomus.*
  - **Front metatarsi shorter than the tibiæ.**
    - **Posterior branch of the fifth longitudinal vein straight** .. .. .. *Orthocladius.*
    - **Posterior branch of the fifth longitudinal vein sinuous** .. .. .. *Camptocladius.*
- **Wings hairy.**
  - **Front metatarsi longer than the tibiæ** .. *Tanytarsus.*

Two basal cells .. .. *Tanypus.*

Genus CHIRONOMUS, Meigen, 1803.

"Antennæ 14-jointed in the male, 7-jointed in the female. Thorax usually with three stripes. Wings naked. Costal vein not extending beyond the tip of the third longitudinal. Fore metatarsus longer than, or occasionally as long as, the tibia. Anal joint of the male abdomen longer than broad, the forceps generally filiform or falcate" Skuse).

KEY TO THE SPECIES.

Thorax pale, with dark stripes.
  Wings without spots.
    Tip of submarginal cell acute .. .. *C. zealandic*
    Tip of submarginal cell rounded .. .. *C. lentus.*
  Wings with two small black spots .. .. *C. opimus.*
Thorax blackish.
  Third longitudinal vein slightly curved near the tip *C. pavidus.*
  Third longitudinal strongly curved near the tip .. *C. ignavus.*

Chironomus zealandicus.

C. zealandicus, Hudson, Man. N.Z. Ent., p. 43, pl. iv., fig. 2 (1892).

First joint of the antennæ pale-yellow, the rest brown, with brown plumes in the male. Clypeus and palpi dark-brown. Thorax pale-yellow, with three longitudinal dark bands, either fuscous or dark-fulvous. The lateral bands start near the middle and gradually narrow to the posterior margin, the central one beginning at the collar and ending near the middle, but continued as a narrow pale-brown median line to the posterior margin. Pleuræ with an oval brown spot under the wing. Scutellum pale-yellow. Metanotum brown. Abdomen brown, with long yellow hairs; each segment bordered posteriorly with pale-yellowish, except the second, which is almost entirely brown. Legs pale-yellow, each joint generally minutely tipped with brown; the last joints of the tarsi slightly fuscous. Fore metatarsus about one and a third times the length of the tibia; intermediate tibia less than twice the length of its metatarsus; each joint of the tarsi shorter than the ones before it. Wings hyaline, glabrous; the costa, cross-vein, and internal portion of the fourth longitudinal brown. Auxiliary vein joining the costa some distance outside of the cross-vein. Second longitudinal indistinct and close to the first. Third longitudinal meeting the costa a little before the apex of the wing; submarginal cell acute at the tip. Fourth longitudinal reaching the margin of the wing a little below the apex. Length, 6–8 mm.; wing, 5½ mm.

Hab. Wellington (Hudson); Christchurch (F. W. H.); Auckland (Suter).

This species is allied to *C. nepeanensis*, Skuse, but

differs from it in the colour of the bands on the thorax and in the fore tibiæ not being brown at the base. The Christchurch specimens have the thorax much darker and less distinctly marked than those from Wellington and Auckland, and might, perhaps, be distinguished as a distinct species.

Chironomus lentus, sp. nov.

Female.—Antennæ tawny, palpi dark-brown, clypeus black. Thorax tawny, with three brown longitudinal streaks each bearing a series of tawny hairs; of these the lateral streaks curve downwards on the sides of the thorax, and the central stripe is narrow. Scutellum tawny. Metanotum dark-brown. Abdomen brown, with short yellow hairs. Legs pale-tawny, the joints fuscous. Fore metatarsi about one and a half times the length of the tibiæ. Intermediate tibiæ not much longer than the metatarsi; each joint of the tarsi shorter than the one before it. Halteres pale-tawny. Wings hyaline, the veins pale-tawny. No spots. Auxiliary vein joining the costa some distance outside the cross-vein. Second longitudinal indistinct, close to the first. Third longitudinal vein meeting the costa at the apex of the wing; submarginal cell rounded at the tip. Fourth longitudinal reaching the margin considerably below the apex. Fork of the fifth longitudinal a little outside the cross-vein. Length, 4 mm.; wing, $3\frac{1}{4}$ mm.

Hab. Christchurch (F. W. H.).

Chironomus opimus, sp. nov.

Male.—Antennæ pale-brown; clypeus brown. Thorax yellowish-green, with a pair of median dark-brown lines close together, bordered outside with tawny; also on the sides, in front of the wings, a kidney-shaped dark-brown spot bordered above with tawny. Scutellum pale-green. Metanotum tawny, broadly tipped with dark-brown. Abdomen bright-green, with yellow hairs; the sixth and seventh segments slightly fuscous. Legs pale-tawny; the distal end of the fore femora, a band in the middle of the intermediate and hind femora (as well as their apices), a broad band at the proximal ends of the fore tibiæ, and narrow bands in the same place of the intermediate and hind tibiæ, as well as the three last joints of the fore tarsi, brown. The fore metatarsus is nearly one and a half times the length of the tibia. Halteres green. Wings with two small black spots, one on the cross-vein, the other at the apex of the fourth posterior cell. The membrane bare, but short hairs on the fourth longitudinal vein and on the anterior branch of the fifth. Third longitudinal much curved backwards near the tip, reaching the costa at the apex of the wing; the submarginal cell rounded at the tip. Auxiliary vein joining the costa opposite the cross-vein. Fourth longi-

tudinal reaches the margin not far from the tip of the third longitudinal. Fork of the fifth longitudinal considerably outside the cross-vein. Length, 4 mm.; wing, 3 mm.

Female.—Thorax fulvous, with three rows of yellow hairs and a brown patch on the pleura before the wing. Abdomen and halteres pale-brown. The rest as in the male.

Hab. Christchurch (F. W. H.); Auckland (Suter).

Chironomus pavidus, sp. nov.

Male.—Head blackish-brown; the antennæ brown, and with brown plumes. Thorax blackish-brown, with two longitudinal rows of scattered tawny hairs. Abdomen dark-brown, with yellowish hairs. Legs pale-tawny, the last joint of the tarsi fuscous; the coxæ brown; the fore metatarsi about one and a half times the length of the tibiæ. Halteres pale-yellow. Wings and veins bare; veins almost colourless; the membrane with pale iridescent spots or patches, one in front of the cross-vein, two in the first posterior cell, another in the fork of the fifth longitudinal vein, and another in the second posterior cell. These spots are not seen by transmitted light. The third longitudinal vein meets the costa a little before the tip; it is not much curved; submarginal cell acute at the tip. Fourth longitudinal ends below the tip and inside the third. Fork of the fifth a little outside the cross-vein. Length, 4½ mm.; wing, 3 mm.

Female.—Wings iridescent, but without spots.

Hab. Christchurch (F. W. H.).

This species differs from *C. nubifer*, Skuse, in the proportions of the fore metatarsi and tibiæ, and probably in colours also.

Chironomus ignavus, sp. nov.

Male and Female.—Dark-brown, scutellum paler, abdomen with pale hairs. Legs pale-tawny, the tarsi fuscous. Meso- and meta-thorax with a raised central ridge. Fore metatarsus about one and a quarter times the length of the tibia. Intermediate metatarsus nearly as long as the tibia. Halteres pale-brown, with dark tips. Wings with a slight tawny tinge, unspotted; veins pale-tawny. Third longitudinal vein much curved backward, meeting the costa near the apex of the wing; submarginal cell rounded at the tip. Tip of the fourth longitudinal further from the apex of the wing than the third. Fork of the fifth longitudinal slightly outside the cross-vein. Length, 4–4½ mm.; wing, 3–3½ mm.

Hab. Christchurch (F. W. H.).

Genus ORTHOCLADIUS, V. d. Wulp, 1874.

"Antennæ 14-jointed in the male, 7-jointed in the female. Thorax with three stripes. Wings naked. Third longi-

tudinal vein straight or slightly curved, going nearly to the apex of the wing. Costal vein sometimes extending a little beyond the tip of the third longitudinal. Posterior branch of the fifth longitudinal straight or a little bent. Legs unicoloured, or only darker at the articulations. Fore metatarsus considerably shorter than the tibia. Forceps of the male slender" (Skuse).

In the New Zealand species, here described, the thorax is not striped.

Orthocladius publicus, sp. nov.

Male.—Uniform dull-brown, the legs rather paler. The fore tibia not much longer than the metatarsus. Abdomen and legs with distant hairs. Halteres brown. Wings pale-brown, unspotted, the veins brown. The third longitudinal vein nearly straight and joining the costa considerably before the tip of the wing, the costa not produced beyond it. Fork of the fifth longitudinal lies outside the cross-vein. The fourth longitudinal ends at the apex of the wing. First longitudinal ends nearer to the cross-vein than to the tip of the third longitudinal. Length, 1¾ mm.; wing, 2 mm.

Female.—The long hairs on the legs are absent.

Hab. Christchurch (F. W. H.).

Orthocladius cingulatus, sp. nov.

Male.—Dark, shining, brown; the sides of the thorax, distal ends of the coxæ, halteres, and anterior portions of the second, as well as of the fourth and fifth abdominal segments, pale-yellow. Legs pale-brown, with short close hairs. Abdomen with a few distant hairs. Fore tibia rather more than one and a half times the length of the metatarsus. Wings hyaline, the veins brown. The first longitudinal vein reaches the costa about halfway between the cross-vein and the tip of the third longitudinal. The third longitudinal reaches the margin a little before the apex of the wing, and the costa is produced slightly beyond it. The fourth longitudinal ends a little below the apex of the wing. The fork of the fifth longitudinal is nearly on a line with the cross-vein. Length, 3 mm.; wing, 2½ mm.

Hab. Christchurch (F. W. H.).

Genus Camptocladius, V. d. Wulp, 1874.

Antennæ 14-jointed in the male, 7-jointed in the female. Wings naked. Third longitudinal vein bent upwards, sometimes short and terminating considerably before the apex of the wing, or running for some distance close along the anterior margin; consequently the first posterior cell is very

broad. Posterior branch of the fifth longitudinal sinuated. Legs unicoloured, usually black. Fore metatarsus considerably shorter than the tibia. Anal joint in the male short and broad; the forceps broad, white, or with white hairs.

Camptocladius vernus, sp. nov.

Blackish-brown, the tibiæ and tarsi brown. Fore tibia about twice the length of the metatarsus. Abdomen and legs hairy. Wings pale-greyish, the veins fulvous, except the costa and the first and third longitudinals, which are blackish. Third longitudinal running near the anterior margin of the wing and ending at a considerable distance before the apex, the costa being produced beyond the tip of the third longitudinal. Fourth longitudinal ending at the apex of the wing, or very slightly below it. The fork of the fifth longitudinal lies outside the cross-vein; the posterior branch is sharply bent backwards to a right angle with the margin of the wing. Length, 2¼ mm.; wing, 2 mm.

Hab. Christchurch (F. W. H.).

A common species, and about the first to appear in spring (October).

Genus TANYTARSUS, V. d. Wulp, 1874.

"Antennæ 14-jointed in the male and 7-jointed in the female. Wings hairy. Third longitudinal vein straight, or nearly straight, running to the apex of the wing. Posterior branch of the fifth longitudinal straight, or only slightly bent backwards. Fore metatarsus longer than the tibia. Forceps of the male slender" (Skuse).

Tanytarsus vespertinus, sp. nov.

Male.—Head black, antennæ and palpi brown. Thorax tawny, with three dark-brown stripes. Scutellum and metathorax brown. Abdomen greenish-brown. Legs tawny; the fore metatarsus nearly one and a half times the tibia. Halteres yellowish-white. Wings with fine hairs, unspotted. The third longitudinal joins the costa at a very acute angle some distance before the apex of the wing, and the costa is not prolonged beyond it. The fourth longitudinal ends very slightly below the apex of the wing. The fork of the fifth longitudinal lies slightly outside the cross-vein. Length, 4 mm.; wing, 3 mm.

Female.—Yellowish-green, the bands on the thorax brownish-yellow. Legs pale-yellowish. The rest like the male.

Hab. Christchurch (F. W. H.).

Genus Tanypus, Meigen, 1803.

"Antennæ 15-jointed. Wings pubescent. Marginal cross-vein and second longitudinal distinct. Fork of the fifth longitudinal situated at the base of the posterior cross-vein" (Skuse).

Key to the Species.

Legs unicoloured, except at the articulations.	
Metanotum dark-brown	*T. languidus.*
Metanotum fulvous	*T. debilis.*
Tibiæ and metatarsi with a dark band in the middle ..	*T. malus.*

Tanypus languidus, sp. nov.

Male.—Antennæ pale-brown, with brown plumes; eyes and face dark-brown. Thorax pale-yellowish, with a double central brown stripe reaching halfway, and a lateral stripe on each side, commencing a little before the end of the median pair; posterior margin of the mesonotum, and a median line from the posterior margin towards the central stripes dark-brown; scutellum pale-yellow; metanotum dark-brown. Abdomen brown, each segment with a square pale-yellow spot on each side, except on the last two segments. Femora pale-yellow, broadly tipped with brown; tibiæ and tarsi tawny. Fore metatarsus about one-half the length of the tibia. Halteres white. Wings hairy, yellowish, with brown spots on all three cross-veins, at the tips of the longitudinal veins, and two each in the first posterior and anal cells; veins yellow. Auxiliary vein rather indistinct, not reaching the costa. Third longitudinal much curved, meeting the costa at the apex of the wing. Posterior branch of the fifth longitudinal meeting the margin of the wing at right angles. Marginal cross-vein joining the costa. Length, 5 mm.; wing, 4 mm.

Female.—Abdomen brown, the anterior portion of each segment pale. Legs pale yellowish-tawny, the tips of the joints brown. Wings broader than in the male, and the marginal cross-vein joining the tip of the first longitudinal. Length, 4½ mm.; wing, 4 mm.

Hab. Christchurch (F. W. H.).

Tanypus debilis, sp. nov.

Male.—Head and antennæ pale-tawny. Thorax pale greenish-yellow, with a double central brown stripe ending halfway, and a brown spot on each side opposite the termination of the stripe. Scutellum pale-green; metanotum pale-tawny, with four brown spots. Abdomen green, the anterior half of each segment darker than the posterior half; the hairs white. Legs pale-tawny, the articulations brown. Fore metatarsus about two-thirds the length of the tibia. Wings hairy; the anal angle white, the rest brownish, with bluish iridescent spots (in reflected light) in the first, second,

and third posterior cells and in the anal cell, these spots being more or less bordered with brown; a dark-brown mark on the cross-veins. Auxiliary vein indistinct. Third longitudinal considerably curved near the tip, meeting the costa a little before the apex of the wing. Marginal cross-vein joining the first longitudinal below its tip. Both branches of the fifth longitudinal strong, the posterior meeting the margin of the wing at right angles. Length, 3 mm.; wing, 4½ mm.

Female.—Abdomen greenish-brown. Wings without iridescent spots. Brown spots on the cross-veins, at the tips of the longitudinals, and near the apices of the first posterior and anal cells.

Hab. Christchurch (F. W. H.).

Tanypus malus, sp. nov.

Male.—Head brown; the antennæ tawny, with pale-brown plumes. Thorax tawny, with two brown median stripes, and a spot on each side, the median bands nearly broken by a tawny curved streak. Scutellum dark-tawny. Metanotum dark-brown. First five segments of the abdomen white, with brown marks on the anterior portion; the rest brown. Legs almost white, with dark articulations and dark median bands on the tibiæ and metatarsi. Fore metatarsus about two-thirds the length of the tibia. Halteres white. Wings hairy, white, with many small dark spots. Third longitudinal not much curved, joining the costa considerably before the apex of the wing. Marginal cross-vein very short, joining the costa. Fourth longitudinal rather weak. Posterior branch of the fifth longitudinal meeting the margin of the wing at right angles. Length, 4 mm.; wing, 3 mm.

Female.—Abdomen brown, banded dark and pale. Length, 3 mm.; wing, 4 mm.

Hab. Christchurch (F. W. H.).

Family TIPULIDÆ (brevipalpi).

Genus RHYPHOLOPHUS, Kolenati, 1863.

"Two submarginal cells; four posterior cells; discal cell present or absent. Wings pubescent on the whole surface. The second longitudinal vein originates at a more or less acute angle before the middle of the anterior margin; the subcostal cross-vein is at a considerable distance (two or three lengths of the great cross-vein) anterior to the tip of the auxiliary vein. Antennæ 16-jointed. Tibiæ without spurs at the tip; ungues smooth on the under-side; empodia distinct" (Osten-Sacken).

This genus differs from *Molophilus* and *Erioptera* in having hairs all over the surface of the wing, instead of on the veins only.

Rhypholophus insulsus, sp. nov.

Pale-tawny, the joints of the antennæ dark-brown at their bases. Palpi brown. An irregular brown dorsal stripe on the abdomen. The last three or four joints of the tarsi fuscous. Halteres pale-tawny. Wings tinged with tawny, the veins darker; all the cross-veins slightly bordered with brown, and a small brown spot at the origin of the second longitudinal vein. No discal cell. Submarginal cross-vein opposite the tip of the auxiliary vein. Third posterior cell with a short petiole. Seventh longitudinal sinuated. Forceps of the male double; the outer pair tawny; the inner pair slender and dark-brown. Length, ♂ 7 mm., ♀ 5–6 mm.; of antennæ, ♂ 9 mm., ♀ 3½ mm.; wing, ♂ 9 mm., ♀ 8 mm.

Hab. Wellington (G. V. Hudson).

Rhypholophus fatuus, sp. nov.

Female.—Dark-brown, the legs nearly black, with two pale rings on the femora, one at the tip the other beyond the middle. Wings rather smoky, darker towards the tips; a dark fascia from the tip of the auxiliary vein to the chief cross-vein; a dark spot on the upper margin of the first basal cell and another at the apex of the second basal cell. Neuration as in the last species.

Hab. Wellington (G. V. Hudson).

I have only one specimen, the antennæ of which have sixteen joints, those of the flagellum with whorls of short hairs.

Genus Opifex, gen. nov.

Two submarginal cells, of which the second is nearly twice as long as the first; four posterior cells; no discal cell. Wings hairy along the veins only. Second longitudinal originates at a very acute angle before the middle of the anterior margin. No subcostal nor marginal cross-veins. Anterior branch of the fourth longitudinal forked, the posterior branch simple. Seventh longitudinal short, straight, not reaching the margin. Tibiæ without spurs at their tips; empodia indistinct or absent. Antennæ 16-jointed. Rostrum short. Proboscis elongated, much longer than the head, cylindrical, rather swollen at the apex. Palpi long, but shorter than the proboscis. Legs short.

This genus differs from *Erioptera* not only in the long proboscis and short legs, but also in the absence of a marginal cross-vein, and in fourth posterior cell being pointed at its base.

Opifex fuscus, sp. nov.

Uniform brown; proboscis, palpi, antennæ, and legs lighter than the body. Wings brown. Second posterior cell

with a long petiole; the posterior cross-vein not in a line with the chief cross-vein. Proboscis about four times the length of the head; palpi about two and a half times its length; the last joint swollen, shorter than the penultimate. Antennæ rather shorter than the proboscis. Length, 5 mm.; wing, 5 mm.

Hab. Wellington (G. V. Hudson).

The short legs, long proboscis, and hairy veins make this species look very like a mosquito.

Genus TROCHOBOLA, Osten-Sacken, 1868.

Trochobola dohrni.

T. dohrni, Osten-Sacken, Berlin, ent. Zeitschr., xxxix., p. 264 (1894). *T. ampla*, Hutton, Trans. N.Z. Inst., vol. xxxii., p. 36 (1900). *T. fumipennis*, Hudson, Man. N.Z. Ent., p. 48 (1892), no description.

I unfortunately overlooked this species and the next when writing my paper on the *Tipulidæ*. The following is Osten-Sacken's description:—

"Head, rostrum, palpi, and antennæ brown, the latter sometimes reddish on the second joint. The proximal part of the flagellum is almost moniliform, the joints 1 to 4 somewhat urn-shaped, with a little brush of microscopic hairs on one side and some scattered longer hairs on the other; the rest of the flagellum has more elongate joints, with scattered short hairs. Thorax brown or reddish-brown, with four dark-brown stripes and a covering of yellowish sericeous pollen. Abdomen reddish-brown, with somewhat darker lateral margins. Legs rather long, yellowish-brown, with a distinct dark-brown space just before the tip of the femora, and a narrower yellow ring immediately proximal of the brown; knees paler. Halteres with a brown knob. Wings nearly the same as in *annulata* and *argus*, but the proximal two-thirds of the second basal cell are filled out, or nearly so, with brown. There is a large brown spot in the region of the stigma, between the third vein and the costa; within it there is a small yellowish spot on the costa, a little beyond the tip of the auxiliary vein, and a round hyaline spot in the proximal end of the submarginal cell; along the apex the distal end of the submarginal and first posterior cells has a dark-brown irregular margin. Male forceps (very much shrunken in drying) has apparently the same structure as that of the European *T. annulata*. Length, from 12 mm. to 16 mm.; length of the wing, from 13 mm. to 23 mm.

"*Hab.* Five males and one female from Professor Hutton, in Christchurch, and Helms, in Greymouth. The first speci-

men I received was from Dr. C. A. Dohrn, and I believe it came from the North Island."

Trochobola venusta.

T. venusta, Osten-Sacken, Berlin, ent. Zeitschr., xxxiv., p. 265 (1894).

"Body brownish; the usual thoracic stripes brown, coalescent, leaving only a paler space in the humeral region; antennæ brownish-yellow, scapus brown; halteres with a brown knob. Femora brownish-yellow, with a brown ring before the tip; tibiæ and tarsi yellowish-brown. Wings: The ocellar spots which distinguish the other *Trochobolæ* exist here too, but are rendered less distinct by the numerous brown irregular spots which fill their intervals. The basal portion of the wing is densely filled with little brown spots, assuming a more or less irregularly ocellar shape, with still smaller brown spots in their centre; the very distinct cross-vein between the sixth and seventh longitudinal veins is clouded with brown; in the middle of the wing a kind of cross-band is formed by larger and darker brown spots, one on the anterior margin, surrounding the origin of the prefurca, the other on the posterior margin, near the end of the sixth vein; the space between the larger spots is filled with irregular smaller ones; upon this dark cross-band follows a subhyaline one, within which the brown spots are more scarce; the distal third of the wing is darker again, containing three large brown spots mottled with paler dots, and leaving an irregular, subtriangular, subhyaline space between them. Length, 9 mm.; wing, 11 mm."

Hab. Greymouth (Helms).

"Easily recognisable by the colouration of the wings." It is evidently related to my *T. picta,* but I think that it is a distinct species, especially as no mention is made of the irregularly shaped discal cell which distinguishes *T. picta.* Baron Osten-Sacken speaks of the wings in both these species as being ocellated, while in my paper I say that they are not ocellated. The explanation of the difference is that I confine the term "ocellated" to a distinct dark ring with a spot in the centre, while Osten-Sacken gives it a wider meaning. In the figure of the wing of *T. picta* * I do not recognise my own drawing.

Limnophila skusei, sp. nov.

Pale yellowish-brown. Proboscis dark-brown; each joint of the antennæ dark-brown near its base. A fuscous stripe on each side of the abdomen. Femora rather darker than the

* Trans. N.Z. Inst., xxxii., pl. iii., fig. 2A.

tibiæ, with an indistinct paler band beyond the middle. Tibial spurs moderately long. Empodia large. Wings pale-yellowish, with five brown spots along the anterior border. Of these the second and third are somewhat horse-shoe-shaped. The fourth is the largest and occupies the stigmatic region. The fifth is close to the tip of the wing. The cross-veins are slightly bordered with brown. The second longitudinal vein is oblique and gently curved at its origin. The subcostal cross-vein is close to the tip of the auxiliary. The first submarginal cell is more than three-fourths of the length of the second. There are five posterior cells. The posterior cross-vein is nearly straight, and arises near the inner edge of the discal cell. Female: Length, 15–16 mm.; wing, 14 mm.

Hab. Wellington (Hudson).

This species comes nearest to *L. sinistra,* but is easily distinguished by the markings on the wings. I have named it after the late Mr. F. A. Skuse, who did so much good work towards getting the Australian *Tipulidæ* into order.

Family RHYPHIDÆ.

Genus RHYPHUS, Latreille, 1802.

One marginal and five posterior cells; a discal cell. Antennæ 16-jointed. Legs slender, moderately long; hind tibiæ with small apical spurs. Eyes contiguous in the male, separated in the female.

Rhyphus notatus, sp. nov.

Reddish-tawny, the flagellum of the antennæ dark-brown. Thorax with five brown stripes, the middle one shorter than the lateral pair; scutellum and metanotum brown. Tips of the femora and tibiæ brown. Halteres pale-yellowish. Wings pale brownish; the pterostigma and the tip, from the discal cell outwards, darkish-brown. A distinct round white spot in the submarginal cell, and another, touching it, in the first posterior cell. A brown spot in the anterior basal cell, and another on the chief cross-vein. Posterior cross-vein bordered with brown. Veins brown. Length, 6 mm.; wing, 6 mm.

Hab: Auckland (H. Suter); Wellington (G. V. Hudson); Christchurch (F. W. H.).

Easily distinguished from *R. novæ-zealandiæ* by the round white spot in the submarginal cell. The thorax and abdomen are lighter in the female than in the male.

Family MYCETOPHILIDÆ.

Sub-family **Sciarinæ**.

Genus SCIARA, Meigen, 1803.

Antennæ 16-jointed, longer in the male than in the female; the joints of the scapus cyathiform, almost bare;

those of the flagellum cylindrical, pubescent, sessile or subsessile; the last joint elliptical or elongate. Legs slender, the coxæ moderately elongated; tibiæ with small spurs. Wings large, microscopically hairy. Chief cross-vein in a line with the second section of the third longitudinal. Furcations of the fifth and sixth veins near the base of the wing.

Sciara marcilla, sp. nov.

Male.—Antennæ rather longer than the head and thorax; the first and second joints pale, the others brown, the joints sessile; eyes not contiguous; palpi dark-brown. Head and thorax dark-brown, the latter with a few black hairs. Abdomen nearly black, with short black hairs. Middle and hind coxæ yellow, the rest of the legs tawny. Halteres brown, with a yellow stalk. Wings colourless, the veins almost black, and bordered with fuscous. The first longitudinal vein joining the costa inside the base of the fork of the fourth longitudinal. Tips of the third longitudinal and posterior branch of the fourth at nearly equal distances from the apex of the wing. Costa continued some distance beyond the tip of the third longitudinal; origin of the third longitudinal situated very slightly beyond the middle of the first longitudinal. Length, $1\frac{3}{4}$ mm.; wing, $2\frac{1}{2}$ mm.

Female.—Head, thorax, and abdomen pitchy-black; the legs tawny. Wings colourless; the veins tawny. Length, 3 mm.; wing, $2\frac{1}{2}$ mm. The rest as in the male.

Hab. Christchurch (F. W. H.).

This species belongs to the same section as *S. finitima*, Skuse, but the eyes are not contiguous above, the abdomen is darker, and the legs are lighter. *S. rufescens*, Hutton, from Dunedin, belongs to the section in which the first longitudinal vein joins the costa outside the base of the fork of the fourth longitudinal.

Genus Trichosia, Winnertz, 1867.

Characters the same as *Sciara*, but the surface of the wings distinctly hairy.

Trichosia remota, sp. nov.

Female.—Uniform reddish-brown, the middle and hind coxæ lighter. Joints of the flagellum subsessile, about one and a half times as long as broad. Fore tarsi longer than the tibiæ; hind tibiæ only with short spurs. First longitudinal vein short, joining the costa at less than half the length of the wing, its tip lying inside the fork of the fourth longitudinal. Origin of the third longitudinal oblique; the chief cross-vein about the same length as the first section of the third longitudinal. The anterior branch of the fourth

longitudinal ends at the apex of the wing; the third longitudinal ends inside the tip of the posterior branch of the fourth. Anterior branch of the fifth is nearly straight; the posterior branch runs near the anterior for some distance and then turns abruptly down to meet the posterior margin. Length, 2 mm.; wing, $2\frac{1}{2}$ mm.

Hab. Christchurch (F. W. H.).

Family BIBIONIDÆ.

Genus DILOPHUS, Meigen, 1803.

Two basal cells; the third longitudinal vein simple; no discoidal cell. Head almost entirely occupied by the eyes in the male, very small and inclined in the female. Palpi 5-jointed; the third joint dilated. Antennæ cylindrical, inserted beneath the eyes; 11-jointed; the third joint a little larger than the others; the last four hardly distinct from each other. Eyes hairy in the male. Prothorax elevated, with two series of spines. Legs hairy; the fore femora thick and grooved; the tibiæ spined in front and terminated by a coronet of eight spines; tarsi with three pulvilli.

Dilophus nigrostigma.

Bibio nigrostigma, Walker, Cat. Dipt. in Brit. Mus., p. 121 (1848). *Dilophus spectabilis*, Nowicki, Mem. der Krakauer k.-k. Akad. d. Wissen., band 2, p. 10 (1875).

Male.—Black, shining, thinly clothed with black hairs. Wings brown, stigma and anterior veins black; the others tawny. Length, $6\frac{1}{2}$–$7\frac{1}{2}$ mm.; wing, 6 mm.

Female.—Thorax variegated with red and black; the fore coxæ and all the femora red; the latter with black tips. The rest as in the male. Length, 9 mm.; wing, 9 mm.

Hab. Auckland; Ashburton.

The legs are hairy in both sexes.

Variety *zealandicus*, Walker, Trans. Ent. Soc. of London, 1858, p. 235 (*Bibio*), differs only in the abdomen of the female being ferruginous beneath.

Hab. Auckland; Wellington; Chatham Islands.

If it should be proved that the variety *zealandicus* is of any importance, and not merely individual, we must then consider this species as dimorphic, for it is impossible, I think, to distinguish the males.

Dilophus insolitus, sp. nov.

Male.—Black, the legs brown and the eyes red; wings clear, with a brown stigma. Fore and middle femora inflated; the hind legs elongated, with the femora and tibiæ

clavate, metatarsus and second joint much swollen, the other joints vasiform. Neuration of the wing the same as in *D. nigrostigma*. Length, 5 mm.; wing, 5 mm.

Female.—Head and antennæ dark-brown, the rostrum brown below. Thorax fulvous. Abdomen brown. Legs fulvous, except the last three joints of the tarsi, which are brown. Wings slightly tinted with yellowish, iridescent, the stigma brown. Legs slender, the joints of the hind tarsi cylindrical. Length, 5 mm.; wing, 5 mm.

Hab. Christchurch (F. W. H.).

This species and the next belong to the same section as *D. varipes*, Skuse (Pro. Linn. Soc. N.S.W., vol. v., p. 636), but the colours are different.

Dilophus segnis, sp. nov.

Male.—Black, the femora and tibiæ piceous; eyes brown. Hind legs elongated, the femora nearly black; femur and tibia clavate, the metatarsus and second joint swollen. Fore femora slightly inflated; middle femora not inflated. Halteres black, with white stalks. Wings hyaline, the stigma blackish-brown. Length, 5 mm.; wing, 4 mm.

Female.—Head and eyes black; thorax, abdomen, and legs dark-brown. Hind legs rather elongated; the femur and tibia clavate, but the metatarsus not inflated. Wings tinged with brown, iridescent; the stigma blackish-brown. Length, 5 mm.; wing, 5 mm.

Hab. Christchurch (F. W. H.).

The legs in both this species and the last are nearly smooth.

Genus Scatopse, Geoffroy, 1764.

One basal cell; third longitudinal vein simple; three posterior cells, the second of which is petiolated. Antennæ cylindrical, 11-jointed, the last four hardly distinct; palpi concealed, of one distinct joint. Eyes reniform. Hind metatarsi shorter than the remaining joints together.

Scatopse carbonaria, sp. nov.

Entirely black, the veins of the wing fuscous. The first longitudinal vein rather more than half the length of the second. The third longitudinal about two-thirds of the length of the wing. The costa extends round the apex of the wing to the posterior branch of the fourth longitudinal. Fork of the fourth longitudinal situated inside the tip of the third longitudinal. Fifth longitudinal not reaching the border of the wing. The wing-fold, between the fourth and fifth veins, forked. Length, 2½ mm.; wing, 2 mm.

Hab. Christchurch (F. W. H.).

Scatopse notata, Linnæus (*Tipula*).

S. longipennis, Skuse, Pro. Linn. Soc. N.S.W., vol. iii., p. 1383, and vol. v., p. 638.

Black, with a white or yellowish mark on each side of the thorax behind the origin of the wing. First longitudinal less than one-third the length of the wing. The third longitudinal more than two-thirds the length of the wing.

Hab. In a letter to Mr. Skuse Baron Von Osten-Sacken says that he has received numerous specimens from New Zealand. No doubt it has been introduced from Europe.

Family ASILIDÆ.

Saropogon fascipes, sp. nov.

General colour blackish-brown. Head and face yellow, antennæ brown, proboscis black. Bristles of the epistome yellow. Thorax with golden spots on the shoulders and on the sides of the metanotum. Scutellum golden. Legs dark-brown; the bases of the femora, knee-joints, the whole of the fore and middle tibiæ, and the basal half of the hind tibiæ brownish-yellow. Halteres pale-yellowish. Wings very pale-brownish, the tips clouded with fuscous. Male: Length, 14 mm.; wing, 10 mm.

Hab. Wellington (Hudson).

A very distinct species, easily distinguished from *S. antipodus* by its darker colour and banded legs.

Family AGROMYZIDÆ.

Milichia picata, sp. nov.

Head silvery; the eyes large, black, nearly round. Second joint of the antennæ broadly oval, reddish-brown, broadly margined with white. Arista minutely pubescent. Bristles on the vertex and front as far as the antennæ. Oral vibrissæ present. Thorax black, with some irregular white marks on the sides; the dorsum with four rows of short setæ, two of which are on the pleuræ and two on the sides of the dorsum. Scutellum yellow, with two black setæ at the end. Abdomen velvety black, the fourth and fifth segments margined posteriorly with white, which is interrupted in the middle on the fifth; the sixth with white marks on the sides. Femora black, the knees tawny; the tibiæ yellow, with two black bands; tarsi pale brownish-yellow. The middle and hind tibiæ with a strong subapical bristle. Halteres white, the stalk pale-yellow. Wings pale-yellowish, with numerous dark-brown spots. Five spots in the marginal cell, nine or ten in the submarginal, eight in the first posterior, three in the second posterior, one or two in the discal cell. Posterior

cross-vein margined. Axillary cell entirely brown. Costa tawny; the veins black, but tawny at their bases. No bristles on the costa. Auxiliary vein completely joined to the first longitudinal; the first basal cell short. Distance between the cross-veins about three times the length of the posterior cross-vein. The posterior cross-vein distant about its own length from the margin. Membrane of the wing pubescent. Length, 2½ mm.; wing, 3 mm.

Hab. Christchurch (F. W. H.).

Art. XVII.—*On a New Fossil* Pecten *from the Chatham Islands.*

By Captain F. W. Hutton, F.R.S.

[*Read before the Philosophical Institute of Canterbury, 6th November, 1901.*]

Plate VIII.

This fine *Pecten* was brought from the Chatham Islands by Professor A. Dendy, and was given to me to describe.

Pecten dendyi, sp. nov.

Shell equivalve, compressed, inequilateral, the posterior end produced. Ears rather unequal; the anterior larger, with five ribs, the posterior with two ribs. Byssal notch almost obsolete. Valves plicated, eight ridges on the left and nine on the right valve. Ridges narrower than the sinuses on the left valve, broader than the sinuses on the right valve. The whole surface, both ridges and sinuses, covered with fine radiating ribs, crossed by delicate growth-lines, which are almost obsolete on the right valve. Length, 2·6 in.; height, 2·3 in.; greatest thickness, 0·7 in.

Locality.—In a calcareous sandstone, Chatham Island.

This species differs from *P. burnetti* in being larger, inequilateral, more compressed, and in having more than seven folds. It is probably of Miocene age. The type is in the Canterbury Museum.

ART. XVIII.—*On the Occurrence of* Alepisaurus ferox *on the Coast of New Zealand.*

By Captain F. W. HUTTON, F.R.S.

[*Read before the Philosophical Institute of Canterbury, 3rd July, 1901.*]

Plate IX.

LAST September three specimens of this fish were found on the beach at Riversdale, sixteen miles south of Castle Point, on the east coast of Wellington. Some time later photographs of two of them were sent to me for determination.* One photograph (Plate IX.) was of a dried head, and is sufficient to settle the genus to which the fish belongs. The other photograph is of a whole fish. It is very inferior to the first, but sufficient can be made out to corroborate the conclusion arrived at from the skull.

The skull closely resembles the figure of the Tasmanian specimen, but differs in the numbers of the large lanceolate teeth in the jaws. In the New Zealand specimen there are two anterior and one median large teeth on each side of the upper jaw. The lower jaw has three pairs of large teeth situated in the middle of the jaw, and opposing the two pairs of anterior teeth of the upper jaw. Also, there is a smaller pair of large teeth near the end of the lower jaw.

Judging from the photograph of the whole fish, I should say that the length of the head was about one-fifth of the whole length, without the caudal, and that the length of the gape was about one-eighth of the length. The dorsal fin is much elevated. The pectorals are long, but terminate at a considerable distance from the ventrals. The caudal lobes are, apparently, equal in length.

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Alepisaurus ferox, Good and Bean. "Oceanic Ichthyology," p. 117, pl. 38, fig. 142 (1895).

* By Mr. R. Barcham, of Masterton.

Art. XIX.—*On a Marine* Galaxias *from the Auckland Islands.*

By Captain F. W. Hutton, F.R.S.

[*Read before the Wellington Philosophical Society, 11th February, 1902.*]

This fish was taken out of the mouth of a specimen of *Merganser australis* during the collecting excursion to the southern islands of New Zealand made in January, 1901, by His Excellency the Earl of Ranfurly. This expedition, which only lasted three weeks, collected twenty-two undescribed species of animals—viz., one bird, one fish, one slug, four beetles (including a new genus), fourteen flies, and one earthworm. In addition, much new information was obtained about the birds and about the development of some of the plants. This shows how much must yet remain to be done.

Galaxias bollansi, sp. nov.

Body elongated, the height being less than one-sixth of the length. Breadth of the head about equal to the height of the body. Length of the head one-fourth that of the body. Diameter of the eye about one-fourth the length of the head, or two-thirds the length of the snout. Lower jaw a little shorter than the upper. Maxillary reaching to the posterior margin of the eye. Length of the pectoral fins two-thirds the distance to the base of the ventral fins. Ventral fins two-thirds of the distance to the anal. The anal fin, when laid back, does not extend to the commencement of the caudal. The least depth of the tail is less than the distance between the end of the dorsal and the end of the tail. Caudal fin rounded. Dark olive-brown, with irregular vertical bands of dark-brown on the tail. A large pale spot on the preoperculum. Fins dark, unspotted.

I have named this fish after Captain John Bollans, of the Government steamer "Hinemoa," who is an acute observer, and takes a great interest in natural history.

The following are the dimensions of the specimen: Length (without caudal), 3·5 in. Depth of the body, 0·55 in. Least depth of the tail, 0·35 in. Length of the head, 0·88 in.; length of the snout, 0·25 in. Diameter of the eye, 0·18 in. Breadth of the head, 0·6 in. Length of pectoral fin, 0·6 in.; of ventral fin, 0·6 in. Distance from base of pectorals to ventrals, 0·9 in. Distance from base of ventrals to anal, 0·9 in. Distance from dorsal to end of tail, 0·55 in.

This species is most nearly related to *G. fasciatus*, but differs from that species in its more elongated form, the larger

maxillary, the short anal fin, and the distance between the dorsal and the caudal, as well as in its markings.

Its eye is rather larger than usual, but I do not think that it is the young of *G. fasciatus*, on account of its large maxillary bone and the pale spot on the preoperculum, which is probably very constant in all ages of the fish. Also, *G. fasciatus* is not known to breed in the sea in New Zealand; the old ones are never caught going down to sea, nor the young ones going up the rivers. The only species of *Galaxias* in New Zealand which breeds in the sea is *G. attenuatus*, and the young, known as whitebait, ascend the rivers in spring in a much earlier stage of development than the present fish.

ART. XX.—*On Mites attacking Beetles and Moths.*

By W. W. SMITH, F.E.S.

[*Read before the Philosophical Institute of Canterbury, 6th November, 1901.*]

THE late Mr. Maskell was the first to record* the occurrence in New Zealand of the parasitic mite (*Uropoda vegetans*, De Geer) attacking the introduced woodlouse (*Porcellio scaber*, Latr.) and a native beetle. The beetle mentioned by Maskell is a species of *Elater*, and generally known as "click-beetles," from the click-like sound they produce when springing off the ground. The larvæ of several species of *Elater* have destroyed enormous areas of gorse fences in New Zealand during the last ten years by consuming the roots of the gorse-plants. I have now to record the occurrence of *Uropoda vegetans* parasitic on eight additional species of beetles and on two species of native moths.

On the 8th September last Mr. Edwin Thomas, of Ashburton, sent me a specimen of *Tricosternus antarcticus*, a large carnivorous ground-beetle, with many thousands of the minute reddish-brown mites adhering thickly to every part of the beetle's body. When the specimen reached me the mites were so numerous that they completely enveloped its body and legs so as almost to conceal it from view. They were nearly ¼ in. in depth on its back, while on the legs, especially the thighs and underparts, they were so matted together that it was with difficulty the beetle could walk. An examination of the parasite with the microscope showed it to be attached to

* Trans. N.Z. Inst., vol. xxv., p. 199.

its prey by an infinitesimally fine thread or cord. I have not seen De Geer's description of *U. vegetans*, but Maskell has defined its structural characters and its method of attachment to its host. Notwithstanding that I have collected several thousand specimens of *Coleoptera* in Ashburton County during the last fifteen years, I have not previously observed this mite parasitic on any specimens I have preserved. Captain Hutton, however, informs me that when collecting *Coleoptera* some years ago he noted it parasitic on several species in the neighbourhood of Christchurch.

Mr. J. H. Lewis, of Ophir, who is an enthusiastic collector and student of New Zealand *Coleoptera*, has also recently informed me that he has observed *U. vegetans* parasitic on the undermentioned species: *Uloma tenebrionides, Lissotes reticulatus, Thoramus wakefieldi, Pterostichus præcox, Æmona hirta, Coptomma variegatum,* and *Xilotoles griseus*. The three first named are wood-eating species, the fourth is a Carabid, and the three last are Longicorns, which shows that many species of beetles of very different habits are liable to be attacked by the mite. Mr. Lewis mentions having also observed it on a fly (unknown) in the Wellington District.

When on a visit to Ashburton lately Mr. G. W. Howes, F.E.S., informed me that he had twice observed *U. vegetans* parasitic on two species of native moths (*Xanthorrhoe beata* and *X. rosearia*) at Invercargill. They were attached to the sides of the thorax and the thighs of the moths. Although the mite would be of great service to man by destroying the destructive *Elater* and detestable woodlice, it is regrettable to see it attacking beautiful and useful native insects. The predaceous ground-beetles are invariably beneficial on farms, but are becoming rare in settled districts. Mr. Howes, my son William, and I, lately spent half a day collecting on the flax flat below the town of Ashburton and near the Ashburton River. Instead of finding great numbers of ants' nests, as formerly, under the half-embedded stones, we found their old homes tenanted by swarms of woodlice, some of them being abnormally large and robust, and very variable in colour. In several parts of this district the woodlice have almost displaced the native ants. Although we searched very carefully we were unable to detect the presence of the mite on any woodlice, or under the cool slightly damp undersides of the stones, to which they occasionally cling in groups. The year Mr. Maskell recorded the occurrence of *U. vegetans* in New Zealand I sent him infested woodlice from Ashburton; but I have not detected them in this neighbourhood since then, until the infested Carabid was received lately from Mr. Thomas. The specimen was found

in a cucumber-frame where woodlice are unpleasantly numerous, but they are apparently free from the mite in the frame.

Some time ago Captain Hutton remarked to me that it would be interesting to know if *U. vegetans* is indigenous or was introduced with *Porcellio*. It has only been detected in certain districts within the last few years, which indicates its being an introduced species now rapidly dispersing in New Zealand. The so-called "red-spider" (*Tetranychus telarius*), so destructive to fruit-trees, is also an introduced mite, common in America, Europe, and Australia.

The habit of some species of beetles and moths of concealing themselves in damp cool places during the day where the mite inhabits would readily enable the latter to attach itself to its host and become parasitic on many species. The milder climate of New Zealand will unquestionably favour its rapid dispersion and increase, as it has done many other both baneful and beneficial species of insects.

ART. XXI.—*Notes on* Coleoptera.

By J. H. LEWIS.

[*Read before the Wellington Philosophical Society, 5th November, 1901.*]

WITH the exception of moths and butterflies, none of the orders of insects occurring in New Zealand can be considered to be catalogued in even a moderately satisfactory manner. The most extensive order, that of *Coleoptera*, is in almost as bad a state as any, for although much has been done and a long list of species published, yet the number of coleopterous insects occurring here is so great and the students so few that it will be many generations before all the forms are described. Description, though a dry and tedious process, is a needful preliminary to the elucidation of the problems connected with distribution and variation, which are the most attractive portions of the study of natural history.

As in other orders, so among beetles, the male insect is often different in form from the female. Not sufficient cognisance has been taken of this fact, except where the describer of a species has himself been able to study the insects in their homes, or where he has attached some weight to the observations of the field naturalist who has collected for him. Some results of this are evident in Captain Broun's list, and a few are noted below with other synonyms. The frequent description of identical species in New Zealand and England

will not cause so much trouble, as in most instances the identity is obvious.

It is not for me to attempt to criticize the work of the able naturalist who has for a quarter of a century studied this order, but the reflection suggests itself that the larger genera might very well be tabulated by the only one who is at present in a position to do so. Among the genera most in need of such a tabulation are *Bembidium*, *Cyphon*, *Acalles*, and the *Pentarthra*. Is it too hazardous to say that when a table cannot be prepared, then the species are not distinct? I have tabulated some families with much advantage to myself, but I am not anxious to publish my work while Captain Broun is able to do the same thing in a more accurate manner.

Descriptions of three new species are submitted, all from the south.

BROSCIDES.

Mecodema bullatum, n. sp.

Elongate, parallel, coppery-black, shining. Head rugosely sculptured, longitudinally on clypeus and above eyes, transversely on vertex, which is sometimes almost smooth. Neck closely punctate. Eyes moderately prominent. Thorax quite similar in shape to that of *sculpturatum*, with strongly crenate margins. The central and basal foveæ are well marked, and the surface has, in addition to moderately distant but conspicuous striæ, a band of punctation along both base and apex. Elytra parallel-sided, rounded behind. Each has eight rows of finely punctured striæ, somewhat obscured by transverse rugosities. The alternate interstices are the widest, and, being interrupted, present each the appearance of being formed of from six to ten oblong flattened tubercles. The lateral sculpture is inconspicuous. The sculpture of the underside is similar to that of *sculpturatum*, but less pronounced. Length, 25 mm.

Puysegur Point; Mr. F. Sandager.

The species belongs to the *sculpturatum* group, and is most nearly allied to *littoreum*, the sculpture of whose wing-cases might easily be developed into that of *bullatum*.

Mecodema infimate, n. sp.

Elongate, parallel, medially narrowed, shining fusconigrous; femora, palpi, and basal joints of the antennæ shining-red. Head with the vertex quite smooth, the occiput punctured, the clypeus and the swollen orbits wrinkled. Thorax elongate, not much narrowed in front but considerably so behind, the sinuation gentle. Its sculpture consists of the usual basal foveæ and central line. The disc bears well-marked transverse striæ, and the apical and basal margins

are strongly striated longitudinally. The basal foveæ are punctured. The elytra have each nine striæ almost without punctures. The alternate interstices are twice the width of the intermediate, and, with the exception of some scattered punctures, are without sculpture. The underside of the head (except the gula), the flanks of the prothorax, and the mesosternum are rugosely sculptured. The abdomen is sparingly punctured. The intermediate tibiæ are strongly punctate, as are the front on the apical half of their inner face. Length, 16 mm.

West Plains, Invercargill; Mr. A. Philpott.

This species may be readily distinguished from the others of small size by the almost simple striæ of the elytra.

LUCANIDES.

Lissotes acmenus, n. sp.

♂. Head and thorax black, shining; abdomen shining-brown. Head finely and obscurely punctured, most densely on the vertex; the hind angles prominent. That portion of the side margin that encroaches on the eye is more prominent than in *helmsi*. Prothorax transverse, wider than the elytra, finely and distantly punctured; not so broad in proportion to its length as in *helmsi;* with a fine medial line and three punctiform impressions, one in the middle of the medial line, the other two midway between that point and the side margin. Its shape is similar to that of *helmsi*, but the base is more markedly sinuate. Elytra short and broad, shining, each with four obscure costæ, which are more finely punctate than the intervals between them. The margins of the thorax and elytra and the four hind tibiæ externally are clothed with short golden setæ, indistinct traces of which are sometimes seen on the elytral costæ. The mandibles are exactly similar to those of smaller specimens of *helmsi*. Length, including mandibles, 20–25 mm.

The female will probably be very similar to the same sex of *helmsi*.

This fine beetle is very closely allied to both *helmsi* and *æmulus;* indeed, Dr. Sharp considers that it is identical with the former species. It is sufficiently easily distinguished by its bright appearance, narrower form, and the smaller size of fully developed individuals. I am indebted to Mr. G. Howes, Invercargill, for a good series of males.

As a first step towards a revision of the catalogue, I would suggest the following synonyms as extremely probable:—

Cicindela dunedinensis, Castelnau = *C. wakefieldi*, Bates.

Mecodema crenaticolle, Redtenbacher = *M. lineatum*, Broun.

Dryocora howittii, Pascoli = *Adelostella punctatum*, Broun.

Parabrontes setiger, Broun = *P. picturatus*, Sharp.
Dasytes stewarti, Broun = *D. nigripes*, Broun.
Echinopeplus dilatatus, Broun = *Heterodiscus horridus*, Sh.
Oreocharis picigularis, Broun, ♂ = *O. bicristata*, Br., ♀.
Acalles maritimus, Broun, ♂ = *A. cryptobius*, Br., ♀.

Art. XXII.—*On the Land Mollusca of Little Barrier Island.*

By Henry Suter.

[*Read before the Auckland Institute, 7th October, 1901.*]

In the Christchurch *Press* of the 21st November, 1892, some notes on Little Barrier Island were published *re* the visits of Messrs. Henry Wright and Boscawen, of the Lands Department, the notes being probably quoted from the *New Zealand Herald*. There occurs the following passage: "He (Mr. Boscawen) also found the pupurangi, or New Zealand snail (*Helix busbyi*), which is about 4 in. or 5 in. long, and lays an egg like that of a bird." It is curious that Mr. Shakespear, the curator of Little Barrier Island, has never found this large snail, nor has Mr. Cheeseman, on his repeated visits to the island, come across it. Possibly Mr. Boscawen's specimen was "the last of the Mohicans." Be this as it may, the fact remains that up to the end of the last century nothing else was known about the land molluscan fauna of Little Barrier Island.

In January last Mr. J. Adams, of the Thames, was paying a visit to the island, and, knowing him to be a very good collector of land-shells, I asked him to have a good look out for these mostly minute and inconspicuous creatures. On Mr. Adams's return he kindly handed over to me the harvest of his collecting, which enables me now to publish the first list of land-shells from this our native reserve. To Mr. Adams I wish to express my gratitude for the great trouble he has taken to get this nice and interesting collection together. No new species were amongst these shells, which belong to four genera and represent twelve species. There is little doubt but that further collecting will produce many additions to the list.

Fam. RHYTIDIDÆ.

(1.) **Rhenea coresia,** Gray.

Distribution.—North Island only, but more common in the northern part of it. It is not uncommon in the bush near Auckland, and occurs also on Chicken Island.

Fam. PHENACOHELICIDÆ.

(2.) **Flammulina (Allodiscus) urquharti,** Suter.

Distribution.—This minute brown shell is, no doubt, easily overlooked; and, on the other side, it must be mentioned that all the species of the subgenus *Allodiscus* are not common shells at all. The type was found on Mount Pirongia, and specimens from the Hunua Range are also in my collection. North Island only.

(3.) **Flammulina (Therasia) celinde,** Gray.

Distribution.—A fairly common shell in the northern parts of the North Island, but has not been found on it further south than the Urewera country. In the South Island it was found in Happy Valley, Canterbury, where also *Phenacharopa novoseelandica,* Pfr., occurs.

(4.) **Flammulina (Therasia) decidua,** Pfeiffer.

Distribution.—Found from Auckland to Otago. This is one of the very few New Zealand snails I have seen leaving its hiding-place after a warm rain and crawling up on shrubs with smooth bark, or devoid of it.

(5.) **Flammulina (Suteria) ide,** Gray.

Distribution.—Occurs over the entire North Island, in moist situations of the bush, and the northern part of the South Island. Its southernmost limit is, to my knowledge, near Lake Mahinapua, where it was found by Dr. A. Dendy.

(6.) **Flammulina (s. str.) pilsbryi,** Suter.

Distribution.—Like most minute forms, this species is widely distributed over New Zealand, and is found on both Islands. In the South Island I found it near the Mueller Glacier in some native bush.

Fam. LAOMIDÆ.

(7.) **Laoma (s. str.) pœcilosticta,** Pfeiffer.

Distribution.—This is a North Island shell, not uncommon in the bush near Auckland, but rare in the southern parts. It is one of the few specifically northern species that has reached the South Island, as specimens were found in Marlborough.

(8.) **Laoma (Phrixgnathus) glabriuscula,** Pfeiffer.

Distribution.—Hitherto only known from Auckland Province, Hawke's Bay, and Taranaki, in the North Island, but, like the foregoing species, also from Marlborough.

(9.) **Laoma (Phrixgnathus) phrynia,** Hutton.

Distribution.—This rather rare species has been found from Whangarei to the Seventy-mile Bush, in the North Island; Marlborough, Nelson, Canterbury, and Hooker Valley, in the South Island; and a variety on Stewart Island.

(10.) **Laoma (Phrixgnathus) allochroida,** var. **lateumbilicata,** Suter.

Distribution.—A very minute form, living in mould in the bush, and hitherto only known from Auckland to the Forty-mile Bush, in the North Island; also from Chicken Island.

Fam. PATULIDÆ.

(11.) **Endodonta (Charopa) coma,** Gray.

Distribution.—This is the only one of our land-shells that can be called common. It is found almost everywhere in the North Island, also on the Great Barrier Island. In the South Island it is, to my knowledge, not found south of the 44th degree of latitude; in the east, towards Banks Peninsula, it is replaced by *Endodonta pseudocoma*, Sut.

(12.) **Endodonta (Charopa) colensoi,** Suter.

Distribution.—The type is from the Forty-mile Bush, and it has also been found near Auckland, and in Hawke's Bay, Waipawa, and Manawatu. Unknown from the South Island.

Thus it will be seen that most of the shells brought from Little Barrier Island are rather widely distributed in our colony.

With regard to the distribution of the genera, I may just mention that *Rhenea*, comprising small carnivorous snails, occurs as far as Queensland, New Caledonia, and one species (*R. gradata*, Gould) on the Tonga Islands. *Flammulina* is also found in Tasmania, Australia, Lord Howe Island, Norfolk Island, New Caledonia, and the Carolines; and nearly allied to it are *Amphidoxa* and *Stephanoda*, from South America, and *Trachycystis*, from South Africa. Once the anatomy of these genera is well known, they will most likely prove to form only one genus. *Laoma*, subgenus *Phrixgnathus*, is also known from Tasmania and southern Australia, but *Laoma* (restricted) is only found in New Zealand. To the same family belongs the genus *Punctum*, which occurs in North America, Europe, part of Asia, and northern Africa. *Endodonta*, a Polynesian genus, occurs also in Tasmania, Australia, New Caledonia, the Philippine Islands, and over the Polynesian islands as far as the Hawaiian and Society Islands.

ART. XXIII.—*List of the Species described in F. W. Hutton's Manual of the New Zealand Mollusca, with the Corresponding Names used at the Present Time.*

By HENRY SUTER.

[*Read before the Auckland Institute, 7th October, 1901.*]

SINCE the publication of the Manual in 1880 considerable changes in nomenclature have taken place, and for many species the New Zealand habitat has proved to be erroneous. The writer has thought that it might be useful to students in conchology to publish the present list. The chief work has been done by Captain Hutton himself in his revisions published in the "Proceedings of the Linnæan Society of New South Wales," which, however, are not always available to New Zealand workers in conchology.

In the first column the names are given in order of the Manual:—

Page

1\. Octopus maorum, *Hutt.* = O. maorum, *Hutt.*
2\. Pinnoctopus cordiformis, *Q. and G.* = P. cordiformis, *Q. and G.*
2\. Argonauta tuberculata, *Shaw* = A. nodosa, *Solander.*
3\. Onychoteuthis bartlingii, *Lesueur* = O. banksii, *Leach.*
3\. Ommastrephes sloanii, *Gray* = Todarodes sloanii, *Gray.*
3\. Sepioteuthis lessoniana, *Fér.* = S. lessoniana, *Fér.*
3\. Sepioteuthis bilineata, *Q. and G.* = S. bilineata, *Q. and G.*
4\. Spirula peronii, *Lam.* = S. peronii, *Lam.*
5\. Patula chordata, *Pfr.* = Flammulina (Phenacohelix) chordata, *Pfr.*
6\. Patula iota, *Pfr.* = Flammulina (Phenacohelix) pilula, *Reeve.*
6\. Patula dimorpha, *Pfr.* = Flammulina (Allodiscus) dimorpha, *Pfr.*
6\. Patula hypopolia, *Pfr.* = Flammulina (Phacussa) hypopolia, *Pfr.*
6\. Patula decidua, *Pfr.* = Flammulina (Therasia) decidua, *Pfr.*
6\. Patula celinde, *Gray* = Flammulina (Therasia) celinde, *Gray.*
7\. Patula ziczac, *Gould* = Flammulina (Thalassohelix) ziczac, *Gould.*
7\. Patula kappa, *Pfr.* = Flammulina (Thalassohelix) ziczac, *Gould.*

Page

7. Patula varicosa, *Pfr.* = Endodonta (Thaumatodon) varicosa, *Pfr.*
7. *Patula tiara*, Mighels, *not New Zealand (Hawaiian Islands).*
8. Patula coma, *Gray* = Endodonta (Charopa) coma, *Gray.*
8. Patula tau, *Pfr.* = Endodonta (Thaumatodon) tau, *Pfr*
8. Patula gamma, *Pfr.* = Endodonta (Charopa) buccinella, *Reeve.*
8. Patula egesta, *Gray* = Endodonta (Charopa) egesta, *Gray.*
9. Patula obnubila, *Reeve* = Flammulina (Thalassohelix) igniflua, *Reeve, var.* obnubila, *Reeve.*
9. Patula anguiculus, *Reeve* = Endodonta (Charopa) anguiculus, *Reeve.*
9. Patula ide, *Gray* = Flammulina (Suteria) ide, *Gray.*
9. Patula eta, *Pfr.* = Endodonta (Charopa) corniculum, *Reeve.*
9. Patula zeta, *Pfr.* = Endodonta (Charopa) infecta, *Reeve.*
10. Patula venulata, *Pfr.* = Flammulina (Allodiscus) venulata, *Pfr.*
10. Patula portia, *Gray* = Flammulina (Thalassohelix) ziczac, *Gould.*
10. Patula omega, *Pfr.* = Flammulina (s. str.) compressivoluta, *Reeve.*
11. Patula tullia, *Gray* = Flammulina (Allodiscus) tullia, *Gray.*
11. Patula lambda, *Pfr.* = Flammulina (Thalassohelix) igniflua, *Reeve.*
11. Patula biconcava, *Pfr.* = Endodonta (Charopa) biconcava, *Pfr.*
12. Vitrina dimidiata, *Pfr.* = Otoconcha dimidiata, *Pfr.*
12. Vitrina zebra, *Le Guillou* = Flammulina (s. str.) zebra, *Le Guill.*
12. Daudebardia novoseelandica, *Pfr.* = Schizoglossa novoseelandica, *Pfr.*
12. Hyalina corneo-fulva, *Pfr.* = Vitrea cellaria, *Müller (introduced).*
13. Hyalina novaræ, *Pfr.* = Xesta novaræ, *Pfr.*
13. Succinea tomentosa, *Pfr.* = Limnæa tomentosa, *Pfr.*
14. Tornatellina novoseelandica, *Pfr.* = Tornatellina novoseelandica, *Pfr.*
14. Placostylus bovinus, *Brug.* = Placostylus hongii, *Lesson.*
14. Placostylus novoseelandicus, *Pfr.* = Placostylus hongii, *var.* novoseelandica, *Pfr.*
15. Placostylus antipodum, *Gray* = Cochlostyla fulgetrum, *Brod. (introduced).*
15. Pupa novoseelandica, *Pfr.* = Endodonta (Phenacharopa) novoseelandica. *Pfr.*

16. *Helix (Rhagada) reinga*, Gray, *not New Zealand (Australia).*
16. Helix (Rhytida) greenwoodi, *Gray* = Rhytida greenwoodi, *Gray*.
16. Helix (Rhytida) dunniæ, *Gray* = Rhytida dunniæ, *Gray*.
17. Helix (Thalassia) regularis, *Pfr.* = Laoma (Phrixgnathus) regularis, *Pfr.*
17. Helix (Thalassia) heldiana, *Pfr.* = Laoma (Phrixgnathus) erigone, *Gray*.
17. Helix (Thalassia) conella, *Pfr.* = Laoma (Phrixgnathus) conella, *Pfr.*
17. Helix (Thalassia) pœcilosticta, *Pfr.* = Laoma (s. str.) pœcilosticta, *Pfr.*
18. Helix (Thalassia) erigone, *Gray* = Laoma (Phrixgnathus) erigone, *Gray*.
18. Helix (Thalassia) alpha, *Pfr.* = Endodonta (Æschrodomus) stipulata, *Reeve*.
18. Helix (Thalassia) beta, *Pfr.* = Endodonta (Æschrodomus) barbatula, *Reeve*.
18. Helix (Thalassia) ophelia, *Pfr.* = Flammulina (Therasia) ophelia, *Pfr.*
19. Helix (Thalassia) zealandiæ, *Gray* = Flammulina (Thalassohelix) zelandiæ, *Gray*.
19. Helix (Thalassia) fatua, *Pfr.* = Laoma (Phrixgnathus) fatua, *Pfr.*
19. Helix (Thalassia) antipoda, *H. and J.* = Flammulina (Thalassohelix) zelandiæ, *Gray*, *var.* antipoda, *H. and J.*
19. Helix (Thalassia) aucklandica, *Le Guill.* = Flammulina (? Thalassohelix) aucklandica, *Le Guill.*
19. Helix (Thalassia) sciadium, *Pfr.* = Laoma (Phrixgnathus) sciadium, *Pfr.*
20. Helix (Thalassia) irradiata, *Gould* = Flammulina (Carthæa) kivi, *Gray*.
20. Helix(?) kivi, *Gray* = Flammulina (Carthæa) kivi, *Gray*.
20. Helix granum, *Pfr.* = Flammulina (Allodiscus) granum, *Pfr.*
20. *Helix guttula*, Pfr., *not New Zealand.*
21. Laoma leimonias, *Gray* = Laoma (s. str.) leimonias, *Gray*.
21. Paryphanta busbyi, *Gray* = Paryphanta busbyi, *Gray*.
22. Paryphanta hochstetteri, *Pfr.* = Paryphanta hochstetteri, *Pfr.*
22. Paryphanta urnula, *Pfr.* = Paryphanta urnula, *Pfr.*
22. Paryphanta phlogophora, *Pfr.* = Flammulina (s. str.) zebra, *Le Guill.*
23. Paryphanta glabriuscula, *Pfr.* = Laoma (Phrixgnathus) glabriuscula, *Pfr.*

Page
23. Paryphanta epsilon, *Pfr.* = Endodonta (Charopa) caputspinulæ, *Reeve.*
23. Paryphanta chiron, *Gray* = Flammulina (s. str.) chiron, *Gray.*
23. *Paryphanta rapida*, Pfr., *not New Zealand.*
24. Paryphanta crebriflammis, *Pfr.* = Flammulina (s. str.) crebriflammis, *Pfr.*
24. Paryphanta jeffreysiana, *Pfr.* = Rhenea jeffreysiana, *Pfr.*
24. Paryphanta coresia, *Gray* = Rhenea coresia, *Gray.*
25. Nanina mariæ, *Gray* = Laoma (Phrixgnathus) mariæ, *Gray.*
25. Limax molestus, *Hutt.* = Limax agrestis, *L. (introduced).*
26. Milax antipodum, *Pfr.* = Amalia gagates, *Drap. (introduced).*
26. Milax emarginatus, *Hutt.* = Amalia gagates, *Drap. (introduced).*
26. Arion incommodus, *Hutt.* = Arion fuscus, *Müll. (introduced).*
27. Janella bitentaculata, *Q. and G.* = Athoracophorus bitentaculatus, *Q. and G.*
27. Konophora marmorea, *Hutt.* = Athoracophorus (Konophora) marmorea, *Hutt.*
28. Onchidella patelloides, *Q. and G.* = Oncidiella patelloides, *Q. and G.*
28. Onchidella nigricans, *Q. and G.* = Oncidiella nigricans, *Q. and G.*
28. Onchidella irrorata, *Gould* = Oncidiella irrorata, *Gould.*
29. Latia neritoides, *Gray* = Latia neritoides, *Gray.*
29. Latia lateralis, *Gould* = Latia neritoides, *var.* lateralis, *Gould.*
29. *Physa wilsoni*, Tryon, *not New Zealand.*
30. „ antipodea, *Sow.* = Isidora antipodea, *Sow.*
30. „ *gibbosa*, Gould, *not New Zealand (Australia).*
30. „ guyonensis, *T.-Woods* = Isidora variabilis, *Gray.*
30. „ novæ-zealandiæ, *Sow.* = Isidora variabilis, *Gray.*
30. „ tabulata, *Gould* = Isidora tabulata, *Gould.*
31. „ variabilis, *Gray* = Isidora variabilis, *Gray.*
31. „ mœsta, *Adams* = Isidora tabulata, *Gould.*
31. „ lirata, *T.-Woods* = Isidora tabulata, *Gould.*
31. „ *cumingii*, Ad., *not New Zealand (Australia).*
32. Planorbis corinna, *Gray* = Planorbis corinna, *Gray.*
32. *Melampus commodus*, Ad., *not New Zealand.*
32. „ *zealandicus*, Ad., *not New Zealand.*
33. *Tralia costellaris*, Ad., *not New Zealand.*
33. „ *adamsianus*, Pfr., *not New Zealand.*
34. Ophicardelus australis, *Q. and G.* = Tralia (Ophicardelus) australis, *Q. and G.*
34. Marinula filholi, *Hutt.* = Marinula filholi, *Hutt.*

Page

34. Leuconia obsoleta, *Hutt.* = Leuconopsis obsoleta, *Hutt.*
35. Amphibola avellana, *Chemn.* = Amphibola crenata, *Martyn.*
35. *Amphibola quoyana*, P. and M., *not New Zealand (Australia).*
36. Siphonaria obliquata, *Sow.* = Siphonaria obliquata, *Sow.*
36. Siphonaria sipho, *Sow.* = Siphonaria zelandica, *Q. and G.*
36. Siphonaria cancer, *Reeve* = Siphonaria zelandica, *Q. and G.*
36. Siphonaria australis, *Q. and G.* = Siphonaria australis, *Q. and G.*
36. *Siphonaria spinosa*, Reeve, *not New Zealand (Natal).*
36. Siphonaria redimiculum, *Reeve* = Siphonaria tristensis, *Leach.*
37. Gadinia nivea, *Hutt.* = Gadinia nivea, *Hutt.*
37. Cyclophorus lignarius, *Pfr.* = Lagochilus lignarius, *Pfr.*
37. " cytora, *Gray* = Lagochilus cytora, *Gray.*
38. Paxillus peregrina, *Gould* = Paxillus peregrinus, *Gould.*
38. Diplommatina chordata, *Pfr.* = Palaina chordata, *Pfr.*
39. Realia hochstetteri, *Pfr.* = Realia hochstetteri, *Pfr.*
39. " egea, *Gray* = Realia egea, *Gray.*
39. " turriculata, *Pfr.* = Realia turriculata, *Pfr.*
39. " carinella, *Pfr.* = Realia carinella, *Pfr.*
40. Omphalotropis vestita, *Pfr.* = Omphalotropis vestita, *Pfr.*
40. Assiminea purchasi, *Pfr.* = Hydrocena purchasi, *Pfr.*
41. *Conus zealandicus*, Hutt., *not New Zealand (Australia)* = C. anemone.
42. Acus kirki, *Hutt.* = Terebra tristis, *Desh.*
42. Pleurotoma buchanani, *Hutt.* = Surcula traillii, *Hutt.*
42. Pleurotoma traillii, *Hutt.* = Surcula traillii, *Hutt.*
43. Pleurotoma zealandica, *Smith* = Surcula cheesemani, *Hutt.*
43. Pleurotoma antipodum, *Smith* = Surcula albula, *Hutt.*
43. Pleurotoma albula, *Hutt.* = Surcula albula, *Hutt.*
43. Drillia novæ-zealandiæ, *Reeve* = Surcula novæ-zealandiæ, *Reeve.*
44. Drillia lævis, *Hutt.* = Drillia lævis, *Hutt.*
44. " maorum, *Smith* = Surcula traillii, *Hutt.*
44. " *æmula*, Ang., *not New Zealand (Australia).*
44. " cheesemani, *Hutt.* = Surcula cheesemani, *Hutt.*
45. Lachesis sulcata, *Hutt.* = Columbella sulcata, *Hutt.*
45. Defranchia luteo-fasciata, *Reeve* = Clathurella sinclairi, *Smith.*
45. Daphnella cancellata, *Hutt.* = Daphnella lymneiformis, *Kiener.*
46. Cancellaria traillii, *Hutt.* = Cancellaria traillii, *Hutt.*
46. " *ampullacera*, Less., *not New Zealand.*

Page
46. Murex zealandicus, *Q. and G.* = Murex zelandicus, *Q. and G.*
47. Murex octogonus, *Q. and G.* = Murex octogonus, *Q. and G.*
47. Murex angasi, *Crosse* = Murex angasi, *Crosse.*
47. Murex candida, *H. and A. Ad.* = Trophon ambiguus, *Phil.*
47. *Typhis cleryi*, Petit, *not New Zealand (Australia).*
48. Trophon ambiguus, *H. and J.* = Trophon ambiguus, *Phil.*
48. Trophon stangeri, *Gray* = Trophon stangeri, *Gray.*
48. *Trophon incisus*, Gould, *not New Zealand (California).*
48. Trophon inferus, *Hutt.* = Trophon inferus, *Hutt.*
49. Trophon dubius, *Hutt.* = Taron dubius, *Hutt.*
49. Trophon paivæ, *Crosse* = Trophon paivæ, *Crosse.*
49. Trophon duodecimus, *Gray* = Trophon duodecimus, *Gray.*
49. Trophon spiratum, *H. and A. Ad.* = Trophon stangeri, *Gray.*
49. *Trophon coronatum*, H. and A. Ad., *not New Zealand (Japan).*
50. Fusus spiralis, *Ad.* = Fusus spiralis, *Ad.*
50. Neptunæa zealandica, *Q. and G.* = Siphonalia mandarina, *Duclos.*
50. Neptunæa caudata, *Q. and G.* = Siphonalia mandarina, *var.* caudata, *Q. and G.*
50. Neptunæa dilatata, *Q. and G.* = Siphonalia dilatata, *Q. and G.*
50. Neptunæa nodosa, *Mart.* = Siphonalia nodosa, *Mart.*
51. Neptunæa traversi, *Hutt.* = Euthria lineata, *var.* traversi, *Hutt.*
51. Euthria lineata, *Chemn.* = Euthria lineata, *Martyn.*
51. Euthria vittata, *Q. and G.* = Euthria vittata, *Q. and G.*
52. Euthria bicincta, *Hutt.* = Euthria vittata, *Q. and G.*
52. Euthria littorinoides, *Reeve* = Euthria littorinoides, *Reeve.*
52. Euthria martensiana, *Hutt.* = Euthria martensiana, *Hutt.*
52. Euthria antarctica, *Reeve* = Euthria antarctica, *Reeve.*
53. Cominella maculata, *Mart.* = Cominella maculata, *Mart.*
53. Cominella testudinea, *Chemn.* = Cominella testudinea, *Chemn*
53. Cominella nassoides, *Reeve* = Cominella nassoides, *Reeve.*
53. Cominella lineolata, *Lam.* = Cominella virgata, *Adams.*
54. „ lurida, *Phil.* = Cominella lurida, *Phil.*
54. „ huttoni, *Kob.* = Cominella huttoni, *Kob.*
54. „ melo, *Less.* = Cominella maculata, *Mart.*
54. „ funerea, *Gould* = Cominella lurida, *Phil.*

Page
54. Cominella quoyi, *Kiener* = Cominella virgata, *Ad.*
54. " lactea, *Reeve* = Cominella lineolata, *Lam.*
55. *Nassa rutilans*, Reeve, *not New Zealand (Australia).*
55. *Nassa nigella*, Reeve, *not New Zealand (Australia).*
55. *Nassa novæ-zealandiæ*, Reeve, *not New Zealand (Philippines).*
55. *Nassa corticata*, Ad., *not New Zealand (Australia).*
56. Purpura haustrum, *Mart.* = Purpura haustrum, *Mart.*
56. Polytropa textiliosa, *Lam.* = Purpura succincta, *Lam.*
56. Polytropa succincta, *Lam.* = Purpura succincta, *Lam.*
56. Polytropa striata, *Mart.* = Purpura striata, *Mart.*
56. Polytropa squamata, *Hutt.* = Purpura striata, *var.* squamata, *Hutt.*
57. Polytropa retiaria, *Hutt.* = Trophon stangeri, *Gray.*
57. Polytropa quoyi, *Reeve* = Trophon stangeri, *Gray.*
57. Polytropa scobina, *Q. and G.* = Purpura scobina, *Q. and G.*
57. Polytropa patens, *H. and J.* = Trophon patens, *H. and J.*
57. Polytropa biconica, *Hutt.* = Purpura scobina, *var.* albomarginata, *Desh.*
57. Purpura tesselliata, *Less.*, *not again recognised.*
58. *Ricinula iodostoma*, Less., *not New Zealand (Polynesia).*
58. Ancillaria australis, *Sow.* = Ancilla australis, *Sow.*
59. Ancillaria pyramidalis, *Reeve* = Ancilla pyramidalis, *Reeve.*
59. Coriocella ophione, *Gray* = Marsenia ophione, *Gray.*
60. *Latirus decoratus*, Ad., *not New Zealand (Andaman Islands).*
60. Mitra obscura, *Hutt.* = Mitra obscura, *Hutt.*
60. " rubiginosa, *Hutt.* = Vulpecula rubiginosa, *Hutt.*
61. *Columbella zebra*, Gray, *not New Zealand (Polynesia, &c.).*
61. Columbella choava, *Reeve* = Columbella choava, *Reeve.*
61. Voluta pacifica, *Lam.* = Scaphella pacifica, *Lam.*
62. Voluta gracilis, *Swains.* = Scaphella gracilis, *Swains.*
62. *Voluta kirki*, Hutt., *not New Zealand* (Vol. flavicans, *Gmel.*).
62. Marginella albescens, *Hutt.* = Marginella infans, *Reeve.*
63. " *vittata*, Hutt., *not New Zealand.*
63. Erato lactea, *Hutt.* = Marginella muscaria, *Lam.*
63. Tritonium australis, *Lam.* = Lotorium nodiferum, *Lam.*
64. Tritonium spengleri, *Chemn.* = Lotorium spengleri, *(Chemn.) Lam.*
64. Tritonium olearium, *L.* = Lotorium olearium, *L.*
64. *Tritonium fusiformis*, Kien., *not New Zealand (Australia).*
64. Ranella leucostoma, *Lam.* = Apollo leucostomus, *Lam.*
65. " vexillum, *Sow.* = Apollo argus, *Gmel.*
65. Dolium variegatum, *Lam.* = Dolium variegatum, *Lam.*

Page

66. Cassis pyrum, *Lam.* = Semicassis achatina, *var.* pyrum, *Lam.*
66. Cassis achatina, *Lam.* = Semicassis achatina, *Lam.*
66. *Cypræa punctata*, L., *not New Zealand (Philippines).*
67. Trivia australis, *Lam.* = Trivia australis, *Lam.*
67. „ coccinella, *Lam.* = Trivia europæa, *Montagu.*
67. Struthiolaria papulosa, *Mart.* = Struthiolaria papulosa, *Mart.*
68. Struthiolaria australis, *Gmel.* = Struthiolaria vermis, *Mart.*
68. Struthiolaria inermis, *Sow.* = Struthiolaria vermis, *Mart.*
68. Struthiolaria tricarinata, *Less.* = Struthiolaria tricarinata, *Less.*
69. Trichotropis inornata, *Hutt.* = Trichotropis inornata, *Hutt.*
69. Scalaria zelebori, *Frfld.* = Scalaria zelebori, *Frfld.*
70. „ lyra, *Sow.* = Scalaria tenella, *Hutt.*
70. Philippia lutea, *Lam.* = Solarium luteum, *Lam.*
71. Janthina communis, *Lam.* = Janthina fragilis, *Lam.*
71. „ iricolor, *Reeve* = Janthina globosa, *Swains.*
71. „ exigua, *Lam.* = Janthina exigua, *Lam.*
71. Natica zealandica, *Q. and G.* = Natica zelandica, *Q. and G.*
72. Lunatia australis, *Hutt.* = Natica australis, *Hutt.*
72. „ vitrea, *Hutt.* = Natica vitrea, *Hutt.*
72. Obeliscus roseus, *Hutt.* = Pyramidella rosea, *Hutt.*
72. Chemnitzia zealandica, *Hutt.* = Turbonilla zealandica, *Hutt.*
73. Odostomia lactea, *Ang.* = Odontostomia angasi, *Tryon.*
73. Eulima chathamensis, *Hutt.* = Rissoina rugulosa, *Hutt.*
74. Cerithidea alternata, *Hutt.* = Potamides alternatus, *Hutt.*
74. Cerithidea bicarinata, *Gray* = Potamides bicarinatus, *Gray.*
74. Cerithidea nigra, *H. and J.* = Potamides subcarinatus, *Sow.*
74. Bittium terebelloides, *Mts.* = Cerithiopsis terebelloides, *Mts.*
75. Bittium exilis, *Hutt.* = Bittium exile, *Hutt.*
75. Triphoris angasi, *Crosse* = Triforis angasi, *Crosse.*
75. Triphoris gemmulatus, *Ad. and Reeve* = Triforis gemmulatus, *Ad. and Reeve.*
78. Melanopsis trifasciata, *Gray* = Melanopsis trifasciata, *Gray.*
78. Melanopsis strangei, *Reeve* = Melanopsis trifasciata, *Gray.*
78. Littorina cincta, *Q. and G.* = Littorina cincta, *Q. and G.*
79. „ cœrulescens, *Lam.* = Littorina mauritiana, *Lam.*

Page
79. Littorina luctuosa, *Reeve* = Littorina cincta, *Q. and G.*
79. „ *novæ-zealandiæ*, Reeve, *not New Zealand.*
79. Risella melanostoma, *Gmel.* = Risella melanostoma, *Gmel.*
79. Fossarina varius, *Hutt.* = Fossarina varia, *Hutt.*
80. Rissoina plicata, *Hutt.* = Rissoia plicata, *Hutt.*
80. „ rugulosa, *Hutt.* = Rissoina rugulosa, *Hutt.*
80. „ purpurea, *Hutt.* = Rissoia subfusca, *Hutt.*
80. „ subfusca, *Hutt.* = Rissoia subfusca, *Hutt.*
80. „ fasciata, *Ad.* = Rissoina fasciata, *A. Ad.*
81. Barleeia flamulata, *Hutt.* = Phasianella huttoni, *Pilsbry.*
81. „ rosea, *Hutt.* = Barleeia rosea, *Hutt.*
81. „ nana, *Hutt.* = Rissoia huttoni, *Sut.*
81. „ impolita, *Hutt.* = Odontostomia impolita, *Hutt.*
81. Bythinella antipoda, *Gray* = Potamopyrgus antipodum, *Gray.*
81. Bythinella zealandiæ, *Gray* = P. antipodum, *var.* zealandiæ, *Gray.*
82. Bythinella egena, *Gould* = P. antipodum, *var.* egena, *Gould.*
82. Bythinella spelæa, *Frfld.* = Potamopyrgus spelæus, *Frfld.*
82. Bythinella fisheri, *Dkr.* = Potamopyrgus corolla, *Gould.*
82. Bythinella badia, *Gould* = Potamopyrgus corolla, *Gould.*
82. Bythinella reevei, *Frfld.* = Potamopyrgus corolla, *Gould.*
83. Potamopyrgus corolla, *Gld.* = Potamopyrgus corolla, *Gould.*
83. Turritella rosea, *Q. and G.* = Turritella rosea, *Q. and G.*
84. „ vittata, *Hutt.* = Turritella vittata, *Hutt.*
84. „ fulminata, *Hutt.* = Turritella fulminata, *Hutt.*
84. „ pagoda, *Reeve* = Turritella pagoda, *Reeve.*
84. Eglisia symmetrica, *Hutt.* = Turritella kanieriensis, *Harris.*
85. Siphonium lamellosum, *Hutt.* = Vermicularia lamellosa, *Hutt.*
85. Cladopoda zealandica, *Q. and G.* = Vermicularia zelandica, *Q. and G.*
85. Stephopoma roseum, *Q. and G.* = Vermicularia rosea, *Q. and G.*
86. Siliquaria australis, *Q. and G.* = Tenagodes australis, *Q. and G.*
86. Trochita scutum, *Less.* = Calyptræa scutum, *Less.*
86. Trochita novæ-zelandiæ, *Less.* = Calyptræa maculata, *Q. and G.*
87. Crypta costata, *Desh.* = Crepidula aculeata, *Gmel.*
87. „ monoxyla, *Less.* = Crepidula monoxyla, *Less.*
87. „ unguiformis, *Lam.* = Crepidula crepidula, *L.*
88. Hipponyx australis, *Lam.* = Hipponyx *sp.*

Page
88. Acmæa pileopsis, *Q. and G.* = Acmæa pileopsis, *Q. and G.*
88. „ cantharus, *Reeve* = Acmæa cantharus, *Reeve.*
88. „ fragilis, *Chemn.* = Acmæa fragilis, *Chemn.*
89. „ corticata, *Hutt.* = Acmæa corticata, *Hutt.*
89. Nerita atrata, *Lam.* = Nerita nigra, *Gray.*
90. *Neritina zealandica*, Recl., *not New Zealand (Polynesia).*
90. Turbo smaragdus, *Mart.* = Turbo helicinus, Born.
91. Turbo granosus, *Mart.* = Turbo granosus, *Mart.*
91. Turbo shandi, *Hutt.* = Astralium(?) shandi, *Hutt.*
91. *Turbo lajonkairii*, Desh., *not New Zealand (Indian Archipelago).*
91. *Turbo undulatus*, Chemn., *not New Zealand (Australia).*
92. Calcar cookii, *Lam.* = Astralium sulcatum, *Mart.*
92. „ davisii, *Stowe* = A. sulcatum, *var.* davisii, *Stowe.*
92. „ imperialis, *Lam.* = Astralium heliotropium, *Mart.*
92. Rotella zealandica, *H. and J.* = Ethalia zelandica, *H. and J.*
93. Anthora tuberculata, *Gray* = Trochus viridis, *Gmel.*
94. Anthora tritonis, *A. Ad.* = Trochus viridis, *Gmel.*
94. Anthora viridis, *Gmel.* = Trochus viridis, *Gmel.*
94. Anthora chathamensis, *Hutt.* = Trochus chathamensis, *Hutt.*
94. Anthora tiarata, *Q. and G.* = Trochus tiaratus, *Q. and G.*
95. *Clanculus variegatus*, Ad., *not New Zealand.*
95. Euchelus bellus, *Hutt.* = Euchelus bellus, *Hutt.*
95. Diloma æthiops, *Gmel.* = Monodonta æthiops, *Gmel.*
95. Diloma hectori, *Hutt.* = Monodonta corrosa, *A. Adams.*
96. Diloma undulosa, *Ad.* = M. corrosa, *var.* undulosa, *Ad.*
96. Diloma nigerrima, *Chemn.* = Monodonta coracina, *Troschel.*
96. Diloma corrosa, *Ad.* = Monodonta corrosa, *A. Adams.*
96. Diloma concolor, *Ad.* = Monodonta æthiops, *Gmel.*
96. Diloma gaimardi, *Phil.* = Monodonta lugubris, *Gmel.*
96. Trochocochlea subrostrata, *Gray* = Monodonta subrostrata, *Gray.*
96. Trochocochlea mimetica, *Hutt.* = Monodonta crinita, *Phil.*
97. Trochocochlea excavata, *Ad. and Ang.* = Monodonta excavata, *Ad. and Ang.*
97. *Chlorostoma niger*, Chemn., *not New Zealand.*
97. Thalotia conica, *Gray* = Cantharidus conicus, *Gray.*
98. Zizyphinus punctulatus, *Mart.* = Calliostoma punctulatum, *Mart.*
98. Zizyphinus granatum, *Chemn.* = Calliostoma tigris, *Mart.*
98. Zizyphinus spectabilis, *Ad.* = Calliostoma spectabilis, *Ad.*

Page

98. *Zizyphinus scitulus*, Ad., *not New Zealand (Australia).*
98. Zizyphinus selectus, *Chemn.* = Calliostoma selectum, *Chemn.*
98. Zizyphinus cunninghami, *Gray* = Calliostoma selectum, *Chemn.*
99. Cantharidus iris, *Gmel.* = Cantharidus iris, *Gmel.*
99. Cantharidus zealandicus, *Ad.* = Cantharidus iris, *Gmel.*
99. Cantharidus purpuratus, *Mart.* = Cantharidus purpuratus, *Mart.*
99. Cantharidus texturatus, *Gld.* = C. purpuratus, *var.* texturata, *Gld.*
100. *Cantharidus jucundus*, Gld., *not New Zealand.*
100. Cantharidus pallidus, *H. and J.* = Cantharidus purpuratus, *Mart.*
100. Cantharidus episcopus, *H. and J.* = Cantharidus pruninus, *Gould.*
100. Cantharidus huttoni, *Smith* = C. tenebrosus, *var.* huttoni, *Smith.*
100. Cantharidus pupillus, *Hutt.* = Cantharidus pupillus, *Hutt.*
101. Cantharidus tenebrosus, *A. Ad.* = Cantharidus tenebrosus, *A. Ad.*
101. Cantharidus rufozona, *A. Ad.* = Cantharidus rufozona, *A. Ad.*
101. Elenchus dilatatus, *Sow.* = Cantharidus dilatatus, *Sow.*
101. Bankivia varians, *Beck.* = Cantharidus varians, *Beck.*
102. Monilea egena, *Gould* = Monilea egena, *Gld.*
102. Gibbula sanguinea, *Gray* = Cantharidus sanguineus, *Gray.*
102. Gibbula simulata, *Hutt.* = Cantharidus dilatatus, *Sow.*
102. Gibbula nitida, *Ad. and Ang.* = Gibbula nitida, *Ad. and Ang.*
102. Gibbula inconspicua, *Hutt.* = Gibbula nitida, *Ad. and Ang.*
102. Gibbula oppressa, *Hutt.* = Trochus oppressus, *Hutt.*
103. Margarita antipoda, *H. and J.* = Gibbula antipoda, *H. and J.*
103. Margarita fulminata, *Hutt.* = Gibbula fulminata, *Hutt.*
103. " rosea, *Hutt.* = Gibbula rosea, *Hutt.*
103. " zealandica, *Sow.* = Monilea egena, *Gould.*
103. Scissurella mantelli, *Woodw.* = Scissurella mantelli, *Woodw.*
104. Haliotis iris, *Mart.* = Haliotis iris, *Mart.*
104. Haliotis rugoso-plicata, *Chemn.* = Haliotis rugoso-plicata, *Chemn.*
104. Haliotis gibba, *Phil.* = Haliotis virginea, *Chemn.*
105. *Haliotis zealandica*, Reeve, *not New Zealand(?).*

Page

105. Haliotis cruenta, *Reeve* = Haliotis rugoso-plicata, *Chemn.*
105. *Haliotis stomatiæformis*, Reeve, *not New Zealand (Australia).*
105. Fissurella squamosa, *Hutt.* = Fissurella squamosa, *Hutt.*
106. Lucapina monilifera, *Hutt.* = Megatebennus moniliferus, *Hutt.*
106. Emarginula striatula, *Q. and G.* = Emarginula striatula, *Q. and G.*
106. *Emarginula australis*, Q. and G., *not New Zealand (Australia).*
106. Tugalia parmophoidea, *Q.* and *G.* = Subemarginula parmophoidea, *Q. and G.*
106. Parmophorus unguis, *L.* = Scutum ambiguum, *Chemn.*
107. Patella magellanica, *Mart.* = Patella strigilis, *H. and J.*
107. Patella inconspicua, *Gray* = P. ornata, *var.* inconspicua, *Gray.*
107. Patella redimiculum, *Reeve* = P. strigilis, *var.* redimiculum, *Reeve.*
108. Patella reevei, *Hutt.* = Patella denticulata, *Mart.*
108 „ argyropsis, *Less.* = Patella radians, *Gmel.*
108. „ affinis, *Reeve* = P. radians, *var.* pholidota, *Less.*
108. „ pholidota, *Less.* = P. radians, *var.* pholidota, *Less.*
108. „ radians, *Gmel.* = Patella radians, *Gmel.*
109. „ denticulata, *Mart.* = Patella denticulata, *Mart.*
109. „ flava, *Hutt.* = P. radians, *var.* flava, *Hutt.*
109. „ antipodum, *Smith* = Patella tramoserica, *Mart.*
109. „ tramoserica, *Mart.* = Patella tramoserica, *Mart.*
109. „ stellularia, *Q. and G.* = Patella stellifera, *Chemn.*
109. „ stellifera, *Chemn.* = Patella stellifera, *Chemn.*
110. „ *stella*, Less., *not New Zealand.*
110. „ earlii, *Reeve* = P. radians, *var.* earlii, *Reeve.*
110. „ flexuosa, *Hutt.* = P. radians, *var.* earlii, *Reeve.*
110. „ rubiginosa, *Hutt.* = Acmæa lacunosa, *Reeve.*
111. Chiton pellis-serpentis, *Q. and G.* = Chiton pellis-serpentis, *Q. and G.*
111. Chiton sinclairi, *Gray* = Chiton sinclairi, *Gray.*
111. Chiton stangeri, *Reeve* = Chiton stangeri, *Reeve.*
111. *Chiton concentricus*, Reeve, *not New Zealand* (= Ch. jugosus, *Gld.*).
112. Chiton sulcatus, *Q. and G.* = Chiton limans, *Sykes.*
112. Chiton insculptus, *A. Ad.* = Chiton canaliculatus, *Q. and G.*
112. Chiton glaucus, *Gray* = Chiton quoyi, *Desh.*
112. Chiton æreus, *Reeve* = Chiton æreus, *Reeve.*
112. Lepidopleurus canaliculatus, *Q. and G.* = Chiton canaliculatus, *Q. and G.*

Pag

113. *Lepidopleurus contractus*, Reeve, *not New Zealand.*
113. Lepidopleurus longicymbus, *Blainv.* = Ischnochiton longicymba, *Q. and G.*
113. Lepidopleurus circumvallatus, *Reeve* = Ischnochiton parkeri, *Sut.*
113. Lepidopleurus empleurus, *Hutt.* = Callochiton empleurus, *Hutt.*
113. *Lepidopleurus rudis*, Hutt., *not New Zealand.*
114. Tonicia undulata, *Q. and G.* = Onithochiton undulatus, *Q. and G.*
114. Tonicia rubiginosa, *Hutt.* = Acanthochitus rubiginosus, *Hutt.*
114. Tonicia lineolata, *Fremly* = Onithochiton undulatus, *Q. and G.*
114. Tonicia atrata, *Sow.* = Plaxiphora subatrata, *Pilsbry.*
115. Acanthopleura cælatus, *Reeve* = Plaxiphora cælata, *Reeve.*
115. Chætopleura nobilis, *Gray* = Eudoxochiton nobilis, *Gray.*
116. Mopalia ciliata, *Sow.* = Plaxiphora suteri, *Pilsbry.*
116. Plaxiphora biramosa, *Q. and G.* = Plaxiphora biramosa, *Q. and G.*
116. Plaxiphora terminalis, *Smith* = Plaxiphora cælata, *Reeve.*
117. Acanthochites zealandicus, *Q. and G.* = Acanthochites zelandicus, *Q. and G.*
117. Acanthochites porphyreticus, *Reeve* = Acanthochites violaceus, *Q. and G.*
117. Acanthochites ovatus, *Hutt.* = Plaxiphora ovata, *Hutt.*
118. Acanthochites violacea, *Q. and G.* = Acanthochites violaceus, *Q. and G.*
118. Cryptoconchus porosus, *Burrow* = Acanthochites porosus, *Burrow.*
119. Carinaria australis, *Q. and G.* = Carinaria australis, *Q. and G.*
119. Buccinulus kirki, *Hutt.* = Actæon kirki, *Hutt.*
119. „ albus, *Hutt.* = Solidula alba, *Hutt.*
120. Bullina lineata, *Wood* = Bullinula scabra, *Gmel.*
120. Cylichna striata, *Hutt.* = Bullinella striata, *Hutt.*
121. Bulla oblonga, *Ad.* = Bulla autralis (*Gray*), *Q. and G.*
121. „ quoyi, *Gray* = Bulla quoyi, *Gray.*
121. Haminea zealandiæ, *Gray* = Haminea zelandiæ, *Gray.*
121. Haminea obesa, *Sow.* = Haminea zelandiæ, *Gray.*
122. Haminea acuticulifera, *Smith* = Haminea cuticulifera, *Smith.*
122. Akera tumida, *Ad.* = Akera tumida, *Ad.*
123. Philine angasi, *Crosse* = Philine aperta, *L.*
123. Aplysia brunnea, *Hutt.* = Tethys brunnea, *Hutt.*
123. „ venosa, *Hutt.* = Tethys venosa, *Hutt.*

Page
123. Aclesia glauca, *Cheesem.* = Notarchus glaucus, *Ch.*
124. Pleurobranchus ornatus, *Cheesem.* = P. ornatus, *Ch.*
124. Pleurobranchæa novæ-zealandiæ, *Cheesem.* = P. novæ-zealandiæ, *Ch.*
125. Doris punctata, *Q. and G.* = Doris punctata, *Q. and G.*
125. „ tuberculata, *Cuv.* = Archidoris tuberculata, *Cuv.*
126. „ granulosa, *Abrah.* = Doris granulosa, *Abrah.*
126. „ longula, *Abrah.* = Doris longula, *Abrah.*
126. „ muscula, *Abrah.* = Doris muscula, *Abrah.*
127. „ lanuginata, *Abrah.* = Doris lanuginata, *Abrah.*
127. „ wellingtonensis, *Abrah.* = Doris wellingtonensis, *Abrah.*
128. „ carinata, *Q. and G.* = Atagena carinata, *Q. and G.*
128. Acanthodoris mollicella, *Abrah.* = A. mollicella, *Abrah.*
128. „ globosa, *Abrah.* = A. globosa, *Abrah.*
129. Phidiana longicauda, *Q. and G.* = Facelina longicauda, *Q. and G.*
130. Dentalium zealandicum, *Sow.* = Dentalium zelandicum, *Sow.*
130. Dentalium pacificum, *Hutt.* = Dentalium zelandicum *Sow.*
131. Hyalea affinis, *d'Orb.* = Carolinia tridentata, *Forskål.*
132. Barnea similis, *Gray* = Barnea similis, *Gray.*
133. Pholadidea spathulata, *Sow.* = Pholadidea tridens, *Gray.*
133. „ tridens, *Gray* = Pholadidea tridens, *Gray.*
133. Teredo antarctica, *Hutt.* = Nausitora antarctica, *Hutt.*
134. Saxicava australis, *Lam.* = Saxicava arctica, *L.*
134. Panopæa zealandica, *Q. and G.* = Panopea zelandica, *Q. and G.*
134. Panopæa solandri, *Gray* = Panopea zelandica, *Q. and G.*
135. Corbula zealandica, *Q. and G.* = Corbula zelandica, *Q. and G.*
135. Corbula erythrodon, *Lam.* = Corbula erythrodon, *Lam.*
135. „ *adusta*, Hinds, *not New Zealand.*
135. „ haastiana, *Hutt.* = Corbula haastiana, *Hutt.*
136. Anatina tasmanica, *Reeve* = Cochlodesma angasi, *Crosse and Fischer.*
136. Lyomia vitrea, *Hutt.* = Thracia vitrea, *Hutt.*
137. Neæra trailli, *Hutt.* = Cuspidaria traill, *Hutt.*
137. Myodora striata, *Q. and G.* = Myodora striata, *Q. and G.*
137. „ plana, *Reeve* = Myodora brevis, *Sow.*
137. „ ovata, *Reeve* = Myodora subrostrata, *Smith.*
137. „ rotunda, *Sow.* = Myodora rotundata, *Sow.*
138. Chamostræa albida, *Lam.* = Chamostrea albida, *Lam.*
138. Mactra discors, *Gray* = Mactra discors, *Gray.*
138. „ murchisoni, *Desh.* = Mactra discors, *Gray.*
138. „ scalpellum, *Desh.* = Mactra scalpellum, *Desh.*
139. „ æquilateralis, *Desh.* = Mactra æquilateralis, *Desh.*

Page

139. *Mactra donaciformis*, Gray, *not New Zealand.*
139. Standella ovata, *Gray* = Standella ovata, *Gray.*
139. Standella elongata, *Q. and G.* = Standella elongata, *Q. and G.*
149. Standella notata, *Hutt.* = Standella elongata, *Q. and G.*
140. Zenatia acinaces, *Q. and G.* = Zenatia acinaces, *Q. and G.*
140. Zenatia deshayesi, *Reeve* = Zenatia acinaces, *Q. and G.*
140. Vanganella taylori, *Gray* = Resania lanceolata, *Gray.*
141. Raeta perspicua, *Hutt.* = Raeta perspicua, *Hutt.*
141. *Cæcella zelandica*, Desh., *not New Zealand.*
141. Psammobia stangeri, *Gray* = Psammobia stangeri, *Gray.*
142. Psammobia lineolata, *Gray* = Psammobia lineolata, *Gray.*
142. Psammobia zealandica, *Desh.* = Psammobia zealandica, *Desh.*
142. Psammobia affinis, *Reeve* = Psammobia affinis, *Reeve.*
142. Soletellina nitida, *Gray* = Solenotellina nitida, *Gray.*
142. „ siliqua, *Reeve* = Solenotellina siliqua, *Reeve.*
143. „ incerta, *Reeve* = Solenotellina incerta, *Reeve.*
143. „ nitens, *Tryon* = Solenotellina incerta, *Reeve.*
143. Tellina alba, *Q. and G.* = Tellina alba, *Q. and G.*
143. „ deltoidalis, *Lam.* = Tellina lactea, *Q. and G.*
143. „ disculus, *Desh.* = Tellina disculus, *Desh.*
144. „ subovata, *Sow.* = Tellina strangei, *Desh.*
144. „ ticaonica, *Desh.* = Tellina ticaonica, *Desh.*
144. „ strangei, *Desh.* = Tellina strangei, *Desh.*
144. „ glabrella, *Desh.* = Tellina glabrella, *Desh.*
145. „ radiata, *Desh.* = Solenotellina radiata, *Desh.*
145. Mesodesma novæ-zealandiæ, *Chemn.* = Mesodesma novæ-zealandiæ, *Chemn.*
145. Mesodesma ovalis, *Desh.* = Mesodesma novæ-zealandiæ, *Chemn.*
145. Mesodesma ventricosa, *Gray* = Mesodesma ventricosa, *Gray.*
146. Mesodesma lata, *Desh.* = Mesodesma ventricosa, *Gray.*
146. Mesodesma spissa, *Reeve* = Atactodea subtriangulata, *Gray.*
147. *Venus nodosa*, Dkr., *not New Zealand (West Africa).*
147. „ oblonga, *Hanley* = Venus oblonga, *Hanley.*
147. „ crebra, *Hutt.* = Venus crebra, *Hutt.*
147. Chione lamellata, *Lam.* = Venus lamellata, *Lam.*
147. „ yatei, *Gray* = Venus yatei, *Gray.*
148. „ stutchburyi, *Gray* = Venus stutchburyi, *Gray.*
148. „ costata, *Q. and G.* = Venus costata, *Q. and G.*
148. „ *lima*, Sow., *not New Zealand.*
148. „ mesodesma, *Q. and G.* = Venus crassa, *Q. and G.*

Page
148. Chione gibbosa, *Hutt.*, *found fossil only.*
149. " *paupercula*, Chemn., *not New Zealand (India).*
149. Callista multistriata, *Sow.* = Meretrix multistriata, *Sow.*
149. " *disrupta*, Sow., *not New Zealand (Australia).*
150. Artemis australis, *Gray* = Dosinia australis, *Gray.*
150. " subrosea, *Gray* = Dosinia subrosea, *Gray.*
150. " lambata, *Gld.* = Dosinia lambata, *Gld.*
150. " carpenteri, *Röm.* = Dosinia lambata, *Gld.*
151. " grayi, *Zittel* = Dosinia grayi, *Zittel.*
151. Tapes intermedia, *Q. and G.* = Tapes intermedia, *Q. and G.*
151. *Tapes fabagella*, Desh., *not New Zealand.*
151. *Tapes galactites*, Lam., *not New Zealand.*
152. Venerupis reflexa, *Gray* = Venerupis reflexa, *Gray.*
152. " paupercula, *Desh.* = Venerupis reflexa, *Gray.*
152. " siliqua, *Desh.* = Venerupis siliqua, *Desh.*
152. " elegans, *Desh.* = Venerupis elegans, *Desh.*
153. *Petricola serrata*, Desh., *not New Zealand.*
153. Cardium striatulum, *Sow.* = Cardium pulchellum, *Gray.*
154. Sphærium novæ-zelandiæ, *Desh.* = Sph. novæ-zelandiæ, *Desh.*
154. Sphærium lenticula, *Dkr.* = Sph. novæ-zelandiæ, *Desh.*
155. Pisidium novæ-zealandiæ, *Prime* = P. novæ-zealandiæ, *Prime.*
155. Lucina divaricata, *Lam.* = Divaricella cumingi, *Ad. and Ang.*
155. *Lucina lactea*, A. Ad., *not New Zealand (Australia).*
156. Diplodonta zealandica, *Gray* = Diplodonta zealandica, *Gray.*
156. Diplodonta globularis, *Lam.* = Diplodonta globularis, *Lam.*
156. Diplodonta striata, *Hutt.* = Diplodonta striata, *Hutt.*
157. Kellia cycladiformis, *Desh.* = Kellya cycladiformis, *Desh.*
157. Solemya parkinsoni, *Smith* = Solenomya parkinsoni, *Smith.*
158. Crassatella obesa, *Ad.* = Crassatellites obesa, *Ad.*
158. " bellula, *Ad.* = Crassatellites bellula, *Ad.*
158. Cardita australis, *Lam.* = Venericardia australis, *Lam.*
158. Cardita zealandica, *P. and M.* = Venericardia australis, *Lam.*
158. Cardita lutea, *Hutt.* = Venericardia compressa, *Reeve.*
158. " *bimaculata*, Desh., *not New Zealand (Tasmania).*
158. " *amabilis*, Desh., *not New Zealand*(?).
159. " difficilis, *Desh.* = Venericardia difficilis, *Desh.*
159. " purpurata, *Desh.* = Venericardia australis, *Lam.*
160. Mytilicardia excavata, *Desh.* = Cardita aviculina, *Lam.*
160. Unio menziesii, *Gray* = Diplodon menziesii, *Gray.*
161. " aucklandica, *Gray* = Diplodon menziesii, *Gray.*

Page
161. Unio zelebori, *Dkr.* = Diplodon zelebori, *Dkr.*
161. „ hochstetteri, *Dkr.* = D. menziesii, *var.* hochstetteri, *Dkr.*
161. „ lutulentus, *Gld.* = Diplodon lutulentus, *Gld.*
162. Barbatia decussata, *Sow.* = Arca decussata, *Sow.*
162. „ pusilla, *Sow.* = Arca reticulata, *Chemn*
163. Pectunculus laticostatus, *Q. and G.* = Glycymeris laticostata, *Q. and G.*
163. Pectunculus flammeus, *Reeve* = Glycymeris laticostata, *Q. and G.*
163. Pectunculus striatularis, *Lam.* = Glycymeris striatulare, *Lam.*
164. Nucula nitidula, *A. Ad.* = Nucula nitidula, *A. Ad.*
164. „ strangei, *A. Ad.* = Nucula strangei, *A. Ad.*
164. „ sulcata, *A. Ad.* = Nucula lacunosa, *Hutt.*
164. „ castanea, *A. Ad.*, *doubtful for New Zealand.*
164. „ *striolata*, A. Ad., *not New Zealand (China).*
165. „ *grayi*, d'Orb., *not New Zealand (South America).*
165. Leda concinna, *A. Ad.* = Leda concinna, *A. Ad.*
165. „ fastidiosa, *A. Ad.*, *doubtful for New Zealand.*
165. „ micans *A. Ad.*, *doubtful for New Zealand.*
166. Solenella australis, *Q. and G.* = Malletia australis, *Q. and G.*
166. Mytilus magellanicus, *Lam.* = Mytilus magellanicus, *Lam.*
167. Mytilus polyodontes, *Q. and G.* = Mytilus magellanicus, *Lam.*
167. Mytilus latus, *Chemn.* = Mytilus latus, *Chemn.*
167. „ edulis, *L.* = Mytilus edulis, *L.*
167. „ ater, *Frfld.* = Volsella ater, *Frfld.*
168. Crenella impacta, *Herm.* = Crenella impacta, *Herm.*
168. Modiola australis, *Gray* = Volsella australe, *Gray.*
168. „ areolata, *Gld.* = Volsella australe, *Gray.*
168. „ fluviatilis, *Hutt.* = Volsella fluviatilis, *Hutt.*
168. Lithodomus truncatus, *Gray* = Lithophagus truncatus, *Gray.*
169. *Lithodomus gruneri*, Reeve, *not New Zealand (West Africa).*
169. Pinna zealandiæ, *Gray* = Pinna zealandiæ, *Gray.*
169. *Avicula glabra*, Gld., *not New Zealand.*
170. „ *fucata*, Gld., *not New Zealand.*
170. Pecten zealandiæ, *Gray* = Pecten zelandiæ, *Gray.*
170. Pecten gemmulatus, *Reeve* = Pecten zelandiæ, *var.* gemmulata, *Reeve.*
171. Pecten multicostatus, *Reeve* = Pecten zelandiæ, *Reeve.*
171. „ *pica*, Reeve, *not New Zealand.*
171. „ australis, *Sow.* = Pecten asperrimus, *Lam.*
171. „ radiatus, *Hutt.* = Pecten radiatus, *Hutt.*

Page
171. Pecten vellicatus, *Hutt.* = Pecten convexus, *Q. and G.*
171. Vola laticostatus, *Gray* = Pecten laticostatus, *Gray.*
172. Lima zealandica, *Sow.* = Lima zealandica, *Sow.*
172. „ angulata, *Sow.* = Lima angulata, *Sow.*
172. „ japonica, *A. Ad.* = Lima bullata, *Born.*
173. *Plicatula novæ-zealandiæ*, Sow., *not New Zealand.*
173. Anomia stowei, *Hutt.* = Anomia stowei, *Hutt.*
173. „ alectus, *Gray* = Anomia alectus, *Gray.*
174. „ cytæum, *Gray* = Anomia cytæum, *Gray.*
174. Placunanomia zealandica, *Gray* = Placunanomia zelandica, *Gray.*
174. Placunanomia ione, *Gray* = Placunanomia ione, *Gray.*
175. Ostrea edulis, *L.* = Ostrea angasi, *Sow.*
175. „ *discoidea*, Gld., *not New Zealand.*
175. „ glomerata, *Gld.* = Ostrea glomerata, *Gld.*
175. „ reniformis, *Sow.* = Ostrea reniformis, *Sow.*

Brachiopoda.

176. Waldheimia lenticularis, *Desh.* = Magellania lenticularis, *Desh.*
176. Terebratella cruenta, *Dillw.* = Terebratella cruenta, *Dillw.*
177. Terebratella rubicunda, *Sol.* = Terebratella rubicunda, *Sol.*
177. Magas evansii, *Davidson* = *young of* Terebratella cruenta.
177. Waltonia valencienni, *Davidson* = *young of* Terebratella rubicunda.
178. *Bouchardia cumingi*, Davidson, *not New Zealand.*
178. *Kraussia lamarckiana*, Davidson, *not New Zealand.*
178. Rhynchonella nigricans, *Sow.* = Hemithyris nigricans, *Sow.*

Art. XXIV.—*Notice of an Electric Ray new to the Fauna of New Zealand, belonging to the Genus* Astrape.

By A. Hamilton.

[*Read before the Otago Institute, 12th November, 1901.*]

Plates X.–XII.

During the cruise of the "Doto" in the southern coastal waters of New Zealand, in the early part of 1900, a specimen was caught in Foveaux Strait, in the seventy-sixth haul, in shallow water, of a cramp-fish or torpedo ray, which appears to be an addition to the list of our New Zealand fishes. I

received the specimen from Mr. Ayson, who was in charge of the experimental trawling, on his return to Dunedin. The fish had been placed with other specimens in a jar of strong alcohol, and presented a very shrivelled appearance, the skin being very loose and full of creases and folds. The shape of the body, excluding the short tail, was nearly circular, being 8 in. in each diameter (Plate X.). The total length of the body, including the tail portion, was $10\frac{3}{4}$ in.

In November of the same year I obtained a fresh specimen of this curious fish from a fish-shop in Dunedin, which had been caught the previous night by the steam-trawler some distance outside of the Otago Heads. The general shape and appearance of this specimen was so unlike the other that I thought they must be different species, but on examination I find no material points of difference, except in the general outline, as shown in the plate. The outline figures there given are mechanically reduced from outlines made by passing a pencil round the edges of the fish while it rested on a piece of paper. I am therefore compelled to think that the first specimen must have been much altered in shape by the action of the spirit.

The proper shape of this interesting fish appears to be more of a long oval than a circle, the measurements being 7 in. in greatest diameter and $14\frac{1}{2}$ in. in length.

The very minute, almost invisible, eyes, the single dorsal, and the position of the vent, place it in the genus *Astrape* of Muller and Henle. In the absence of further specimens (both those obtained being males), and not having the necessary literature, I cannot say that it is absolutely the same as *Astrape capensis*. I have therefore, as already intimated in my report of the 5th July, 1900, called the New Zealand specimens *Astrape aysoni*, after their first discoverer.

The British Museum catalogue records *Astrape capensis* from the Cape and from the coast of Madagascar, and an allied species is recorded from Japan, but I cannot get any description for comparison with the New Zealand specimen, nor any illustrations.

Family NARCOBATIDÆ.

Genus ASTRAPE, Mull. and Henle.

Astrape, Mull. and H.

Tail with a fold on each side. Body entirely naked; upper surface reddish-brown, lower surface white and yellowish-white. One dorsal fin only on the tail, without spine. Caudal well developed. Anterior nasal valves confluent into a broad flap overhanging the mouth. Teeth pointed; dental laminæ scarcely extending beyond the other margin

of the jaws. Spiracles immediately behind the eyes, which are very minute, and hardly traceable under the skin. An electric apparatus between the head and pectoral fins.

EXPLANATION OF PLATES X.-XII.

PLATE X.

Astrape aysoni, n. sp.

PLATE XI.

Astrape aysoni, head.

PLATE XII.

Astrape aysoni, under-surface: fig. *a* from live specimen; fig. *b* from spirit specimen; fig. *c*, tail.

ART. XXV.—*Embryology of New Zealand* Lepidoptera: *Part II.*

By AMBROSE QUAIL, F.E.S.

[*Read before the Philosophical Institute of Canterbury, 11th February, 1902.*]

Plate XIII. (See also pl. ix., vol. xxxiii.)

EMBRYOLOGY in interest supersedes the pleasures of collecting and preserving specimens in the imago stage, and enhances the scientific value of the *Lepidoptera* in entomology. Breeding insects is a means towards an end—good specimens to the collector. On the other hand, the desire of the student is to know what can be learnt of structure, habits, and so forth. I know prominent embryologists in England who, after devoting great attention to breeding and hybridizing species, hand over the resulting imagines to some collector friends.

Probably most collectors would at once kill and set a female specimen of any scarce or rare species, if in perfect condition, but an embryological student would almost certainly try and procure ova. Such a case I well remember. A party of several entomologists were at the New Forest, England, and my friend Mr. Arthur Bacot took a freshly emerged female of a scarce species—*Peridea trepida*, I think—which he decided to keep until night and try to assemble some males. Any other of the party would have killed it at once, on the principle of "a bird in the hand is worth two in the bush." That evening, before sugar commenced, we hung her ladyship like a songster in a cage, from a branch of

a tree. Later on she caused an assembly of the opposite sex of her species, and as they hurried up we could see their little eyes glow in the darkness quite a distance away. They would fly straight to the cage and crawl all over the gauze sides, and the light from our lantern did not scare them. As they flew up we netted them, until quite a number of males had been taken; and when the flight was over one was let into the cage, when it immediately copulated and fertile ova resulted. The captured males were handed over to the other entomologists present.

For the purpose of embryology and of classification it is necessary to describe the pattern of the ovum, the structure of the larva and pupa. Although we may not know the why or the wherefore, there must be some functional, constitutional, or environmental reason for such structures. Without further preface I will now offer for your consideration such observations on some species of New Zealand *Lepidoptera* as my limited time has permitted.

A Contribution to the Life-history of *Metacrias* (Meyr.) *strategica* (Hdsn.).

For my material I am indebted to Mr. George Howes, who recorded the occurrence of this species at Invercargill.* The apterous female of this and of the two congeneric species raises the interesting problem of the cause of such a condition. The Arctid genus *Ocnogyna*, of Europe, has females with rudimentary wings, but I know of no others in the group. *Liparidæ*, which by derivation must have more or less remote affinities with Arctids, have some completely apterous females, some with rudimentary wings. Other groups of *Lepidoptera* not associated with these exhibit the same phenomena. Such must be considered specialised, and the apterous condition of the female is intimately associated with reproduction. Lessen productivity and the species is nearer extinction. Whether specialisation of the ovum and its chemical contents is the great factor in reduction of productivity can hardly be proved, but I am inclined to think it is so. The organism, after exclusion from the egg, builds up physiologically from matter assimilated as food; but before exclusion from the egg the organism is formed entirely from matter contained within the egg, derived wholly from the female parent (granted seminal stimulus of the male) by the primary unicellular germ using up surrounding cells in the ovary of the parent until the ovum developed. This, at least, is as I understand the process. The quantity of cellular matter absorbed per ovum would affect the quantity of ova resulting; specialisation

* Trans. N.Z. Inst., vol. xxxiii.

no doubt would cause greater absorption, and consequent reduction, in number of ova. This might be partially counteracted by conversion of energy towards the formation of cellular matter in the ovary at the expense of imaginal structures, until, as in *Metacrias*, the female becomes a helpless ova-bag.

In his letters Mr. Howes tells me that a male *M. strategica* copulated with three separate females in the course of perhaps twenty-four hours. It is interesting to get authentic records of such. Many entomologists believe the males among *Lepidoptera* only pair once. I have no doubt male *M. strategica* would assemble to a virgin female if exposed at the proper time of flight and in a suitable locality.

Ovum.

Deposited, 4th November, 1900; hatched, 27th November, 1900—23 days. Spherical in shape; pale honey-colour; eggshell apparently exceedingly thin, with irregular hexagons over its surface, more distinct than on *Nyctemera annulata.* It may here be noted that I have examined batches of *N. annulata* ova which were quite smooth, others having a faint hexagonal pattern. Mr. Howes mentions that the young newly hatched larvæ eat the eggshell. This is done by *N. annulata.**

Larva. (Plate XIII., fig. 8; vol. xxxiii., pl. ix., fig. 18.)

Newly hatched.—Robust; all the segments approximately uniform except head, prothorax, and the two posterior abdominal segments, which are smaller than the others. Tubercles are crowded together and give the larva a rather dark colour, though the skin is yellowish-brown. The head, scutellum, dorsal anal shield, and tubercles are brown; the setæ are black. The setæ are spinulose, and the skin is covered with minute (secondary) hairs. At first the head appears to be larger than prothorax, but, enclosed in its chitinous envelope, it does not grow, and prior to ecdysis the prothorax is larger than the head. The dorsal and lateral multisetiferous tubercles are at first prominent elevations on all the segments, but when the skin is fully distended prior to ecdysis the dorsal tubercles of 9th abdominal segment only appear to be specially prominent. When full fed in first skin the length is $\frac{3}{16}$ in., and there is a slight reddish mottling on the skin.

Head: The ocelli are crescentic; the numerous hairs are spinulose.

Prothorax: Dorsal shield has on each side of the median

* Entom., vol. xxxiv., p. 141.

line three anterior marginal setæ and two posterior setæ. Supraspiracular and prespiracular tubercles each have three setæ. The spiracle is circular in shape, and posterior. A tubercle above the legs has two setæ.

Meso- and post-thoracic segments: Trapezoidal tubercles appear to be coalesced, forming large dorsal tubercles with about six setæ. Supraspiracular has about eight setæ, slightly below which a small posterior (subspiracular) tubercle has a single very fine seta; a larger anterior subspiracular tubercle has a single seta. Tubercles above the legs have two setæ.

The thoracic legs have spinulose hairs, and terminate with a long claw, a rudimentary claw, and a flattened seta, to which Dr. Chapman gives the name "battledore palpus" in describing *Arctia caia.**

Abdominal segments (vol. xxxiii., pl. ix., fig. 18): Anterior trapezoidal tubercle has three setæ, posterior trapezoidal one seta. Supraspiracular tubercle is anterior above the small circular spiracle, and has about seven setæ. One subspiracular tubercle is below the spiracle, but posterior to it, with one seta, and almost beneath this, but a little anterior, is another, with a single seta, and still lower a tubercle-like area without seta. On the base of abdominal feet are one spinulose seta, one smooth seta; on the footless segments 1 and 2 these rise from a subventral tubercle and are both spinulose; the subventral tubercle of segments 7 and 8 have only one seta (spinulose). Segment 9 has a very large dorsal multisetiferous tubercle, one lateral, one subventral, each with only one seta. Segment 10 has a dorsal multisetiferous tubercle, a lateral spinulose seta, and some setæ on claspers; also on each side of the anal orifice a single smooth seta curved upwards. On all the segments one seta of each supraspiracular tubercle is about twice the length of any other. Mr. Howes mentions the presence of several long grey hairs from the anal extremity. This is a very striking feature, and persists, I believe, until the larva is full fed. These hairs are actually the post-trapezoidal setæ of abdominal segments 7 and 8, which are about four or five times the normal length, are spinulose throughout, and greyish beyond.

Second Skin.—Length immediately after ecdysis $\frac{3}{16}$ in. The tubercles, being more setiferous, are larger, and form very prominent elevations on all segments. The skin is yellowish-brown, the setæ brown and spinulose.

Head has spinulose setæ, but not noticeably more numerous than in first stage.

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* Ento. Record, vol. 4, p. 267.

Prothorax: Dorsal tubercle very prominent, having about a dozen anterior and two posterior setæ on each side. Supraspiracular tubercle about three setæ, prespiracular about ten setæ; spiracle posterior; tubercle above leg has about ten setæ.

Meso- and post-thorax: The dorsal tubercles (medio) appear to be coalesced, and are exceedingly setiferous. A subdorsal and two other tubercles are one below another, with about ten to fourteen setæ each; a smaller tubercle, slightly anterior, above the legs bears three or four setæ. Above the subdorsal tubercle is a small posterior tubercle with one seta.

The thoracic legs terminate as in the preceding stage.

Abdominal segments: Anterior trapezoidal about a quarter the size of posterior, and bears three setæ; post trapezoidal bear ten setæ. Supraspiracular is midlateral, bearing about fourteen setæ. The spiracle is immediately anterior to the uppermost seta of the post subspiracular tubercle, which bears about ten setæ. Immediately below this the other subspiracular bears the same number of setæ, and below this a small tubercle bears three setæ. The abdominal feet bear several single setæ.

The numerous setæ render it extremely difficult to make a description which is absolutely accurate. The larva lived until about three-quarter grown, and I did not observe any further structural difference. The setæ throughout were brown, but the subspiracular setæ were lighter brown than the dorsal setæ. Mr. Howes states that the larva, when full fed, is 1¼ in. in length.

Pupa. (Plate XIII., figs. 9, 10.)

The pupa is enclosed in an oval cocoon of coarse silk threads interwoven with larval setæ. The cocoon is rather dark-brown in colour, and the enclosed pupa can be seen through it.

Male pupa: Length, about ⅝ in.; at widest, ¼ in. Colour very dark-brown, with paler incisions. Wing-cases extend to the middle of 4th abdominal segment ventrally. Abdominal segments 5 and 6 are free; 7, 8, 9, 10 are consolidated and lessen rapidly, forming a rounded extremity with a rather sharp terminal process. The anal armature consists of about twelve stout bristles, with innumerable sharp points at their clubbed end (fig. 10). The anal armature of *Nyctemera annulata* (fig. 11) consists of numerous hooks, not straight bristles, and under a high power these are seen to be ball-tipped, resembling closely the anal armature of some *Noctuæ* (fig. 7, *Melanchra mutans*). In the position of larval tubercles numerous rudimentary setæ, pale yellowish-brown in

colour, resemble the longitudinal yellow spots on the pupa of *Nyctemera annulata*. On dehiscence the wing-cases separate from the ventral juncture and along the sides of the abdominal segments to the suture with thoracic segments, which separate mid-dorsally, and remain attached to either wing-case. The face, antennæ, and leg-cases remain welded together, but separate from the wing-cases almost to the juncture of the 5th abdominal segment.

Female pupa about the same length as male, but extremely robust in comparison. It tapers sharply from the 3rd abdominal segment to head, dorsally and laterally; 4, 5, 6 appear to be wholly free segments, and are the widest—fully $\frac{5}{16}$ in.; 7, 8, 9, 10 are consolidated and form on extremity, with armature similar to the male. Small wing-cases extend to the posterior edge of 3rd abdominal segment, and abdominal rudimentary setæ correspond to the male. The head also is covered with numerous similar setæ.

Duration of pupal existence, about twenty days.

[Since my paper was written I received from Mr. George Howes several larvæ of *Metacrias strategica*, which, after very little feeding, pupated in the usual cocoons amongst moss or grass, and subsequently produced several male and female imagines. I may say, so far as colouration or size is concerned, there appeared to be no difference between the several larvæ such as might be interpreted as an indication of sex. Owing to the fact that the female did not leave its cocoon, I was unaware of it for at least several days, when it appeared to me to be dead, but had already deposited several ova—pale-yellow colour, with distinct hexagonal sculpture. On emergence the female entirely ruptured the pupa-case at every suture, and only remnants remained intact. The female certainly deposits its ova in a normal and proper manner amongst the wool which lines the cocoon. This wool (hair-like scales) acts as an envelope, possibly incubator, for the ova, in the manner observed amongst *Psychidæ*.* *M. strategica*, however, has wool all over its body; but at the time of my examination this had been almost entirely rubbed off, except from the two or three posterior segments. Probably when the burden of ova has been disposed of the empty female *M. strategica* crawls out of the cocoon, as is the case with *Psychidæ*. In my previous remarks I was under the impression that the female *M. strategica* was entirely apterous. This is not strictly so, as there are rudiments of both fore and hind wings, though so small as to be entirely functionless. The several organs of the caput are better developed than are those of the female *Œketicus omnivorus*, which latter has,

* Dr. Chapman, Trans. Ent. Soc., Lond., 1900, 403.

however, a greater capacity for the production of ova as regards quantity. With regard to assembling males of *M. strategica,* I have received a note to the effect that Mr. Philpott, of Invercargill, was successful in taking a large number by exhibiting virgin females. No doubt similar results would be obtained with other species of this genus.]

A Contribution to the Life-history of *Melanchra* (Hb.) *mutans* (Walk.).

Ovum. (Plate XIII., figs. 1, 2, 3, 4.)

A batch of ova was found on the 14th April, 1901, which hatched on the 19th April, 1901. The parent female had pushed them between a blade and stem of withered grass, where they were effectually hidden. The ova were laid in two parallel rows of six each, three others separate, and two rows of three each were laid on top of the first; total number, twenty-one.

Ova: Dull to the naked eye, shining under the microscope. Colour, pale-whitish, upper half irregularly coloured a dirty brown. Shape, a flattened sphere—*i.e.*, wider at equator than in vertical section. Micropyle at top with irregular hexagons, from which strong corrugations diverge towards the equator, converging below. About one in three of the corrugations coalesce with another at the shoulder of the egg, and there is irregularity in this respect: in more than one instance three corrugations coalesce. About twenty-one corrugations meet the micropylar depression. Between the corrugations equidistant finer lines apparently form four-sided figures, but, examined with a higher power, it is found they are really modified hexagons, with strong longitudinal sides. The evolution of parallel ribs on specialised ova from more primitive hexagonal forms is here clearly evidenced.

The contents of a female abdomen were microscopically examined. Within the abdomen the ova are pale-green in colour, placed end on end, pressed flat against each other, so forming continuous rouleaux of ova, from which each ovum is easily separable. This fact is due to the absence of connecting-tissue such as envelopes the ova of *Hepiali* within the abdomen.

The exact process is, necessarily, not easy to detect, but I was fully satisfied that the rouleaux of ova are bathed lengthwise by a fluid (fat?). So long as this continues the ova are smooth, but as activity decreases and the quantity of fluid diminishes on exposure to the air sculpturing appears on the eggshell. When quite dry the ova have the orthodox sculpture of deposited ova.

That the sculpture is due to the fluid is nearly certain—

i.e., in the process of drying it forms into natural crystalline shapes. Of course, this crystalline formation would occur so rapidly on deposition of the ova that it would be difficult, if not impossible, to detect. It is probable, however, that the bathing of the ova continues until the ovum is excluded from the oviduct.

At the top of the egg-mass, where the incision would be first made, a few ova remained smooth when dry. This detracts nothing from the foregoing, as I conclude that these, being earliest exposed to air, were insufficiently bathed by the necessary sculpture-producing fluid.

The results of this examination justify the conclusions suggested by the experiments of Messrs. Woodhead and Dawson, to which I refer in Part I. of this paper.

Larva. (Plate XIII., figs. 5, 6.)

The first meal consists of the empty eggshell, and, though frequently disturbed so that the larvæ moved away or dropped by a thread, they invariably returned and recommenced feeding on the eggshells.

Newly hatched.—Robust, slightly tapering towards posterior; head large and long, tubercles prominent, setæ long and widened at tip. The first two pairs of abdominal feet are small, that of segment 3 being little more than large tubercles provided with hooks. Neither pair of segments 3 and 4 seems to be used, so the larva in walking progresses in semilooper manner (fig. 5). Colour, reddish. Skin smooth.

Head: Setæ pointed, mandibles serrate.

Prothorax: Scutellum bears on each side two separate anterior and two posterior setæ. Supraspiracular tubercle bears two setæ; prespiracular two setæ (?); tubercle above legs two setæ. Meso- and post-thorax, three single-seta tubercles, one below the other; one anterior and one posterior lower each with one seta.

Abdominal segments: All the tubercles bear a single seta. Trapezoidals normal. Supraspiracular beneath the anterior trapezoidal and above the round spiracle, immediately posterior to which is one subspiracular tubercle, and below the spiracle is the other. The abdominal feet bear two single-pointed setæ, which are subventral on segments 1 and 2. On segments 7, 8, and 9 there seems to be only one subventral seta each; segment 10 has all pointed setæ. Two subdorsal posterior, curved downward, two posterior, curved upward, and two on each of the claspers.

On the 1st May some of the larvæ had changed to second and some to third skins.

Second Skin. — Colour, pale-green, head pale-brown;

tubercles, setæ, and spiracles brown; faint pale spiracular line, the skin above being really darker than below. Anterior segments darker than posterior.

Structure: Prothorax (fig. 6) apparently as in first stage. Meso- and post-thorax have an additional tubercle. Careful comparison of first and second stages induces me to think this is not the one immediately above the leg, but the posterior tubercle above it in position. Abdominal segments also have an additional tubercle above the legs in a posterior position. The posterior subspiracular tubercle appears to be rather lower down in relation to the spiracle than in the first stage. The abdominal feet bear three pointed setæ; the first two pairs are larger than in first stage.

In succeeding changes of skin the abdominal feet gradually become normal. This, I think, takes place not earlier than the fourth skin, but I have no note on this point. Adult markings are also gradually assumed. In that skin preceding the last, two larvæ confined in the same pot of grass assumed entirely different plumage as regards colour, one being wholly green, the other brown (this was probably green, more or less, ventrally, but I omitted to note). This striking difference is not unusual amongst *Noctuæ* larvæ, and appears to be attributable to environmental causes. One at least frequently rested during the day-time on the reddish earthenware pot. In a state of nature they rest on the earth, or on a stem of food near the earth. The exciting cause of the variation may be considered to depend on whether the larva rests habitually on the earth or on the stem. In the former case we might expect them to assume a brown colouration, in the latter green, each being to respective individuals equally protective during the period of rest from feeding.

Immediately preceding pupation the length is about 1 in.; colour above spiracular line reddish-brown, below pale-green (the larva mentioned above lost its green colour at last ecdysis). A rather indistinct medio-dorsal line is marked more distinctly at the incisions as a brown spot. Thin dark subdorsal line is edged with lighter, and very distinct dark spiracular spots on all the segments. In preceding stage these were oblique dashes. The clypeus of head is dark-brown, middle of lobes a dark streak, edges dark-brown. Under the microscope the larva-skin is mottled, and the pattern of markings not apparent. No doubt the larva is more inconspicuous to small foes than to our eyes, which take the whole form and markings at one comprehensive glance. Even so, to us the larva seems wonderfully protected by its colouration when at rest.

I omitted to note the exact duration of larval existence.

Pupa. (Plate XIII., fig. 7.)

Colour, reddish-brown; length, $\frac{9}{16}$ in.; widest at 4th abdominal segment. Wing-cases extend to posterior ridge of 4th abdominal ventrally; hind-wing margins show laterally from post-thorax to anterior edge of 4th abdominal. On dehiscence the headpiece, leg-covers, antennæ, and proboscis-covers remain intact, but separate throughout their length from the wing-cases. Spiracles are transverse and fully developed on 2nd to 8th abdominal segments; on 2nd and 3rd the position is subdorsal, on others normal. Posterior edges of 4th, 5th, and 6th abdominal segments form prominent ridges; the other segments are smooth and taper gradually to the 10th viewed laterally and dorsally, but ventrally the 10th is depressed suddenly from the suture to anal armature.

The anal armature is more especially a dorsal apparatus, though the two strong hooks are terminal processes. On the dorsum there are two pairs of weaker hooks. Somewhere I believe I have seen a statement of Dr. Chapman in which he says that the more he studied the structure of the pupal anal armature the less value it seemed to be. With this species and *M. composita* (vol. xxxiii., pl. ix., fig. 21) there is decided affinity in the anal armature, which in both consists of six hooks, yet there is abundant specific distinction.

The moths emerged about the 10th September, 1901.

A Contribution to the Life-history of *Asaphodes* (Meyr.) *megaspilata* (Walk.).

Ovum. (Vol. xxxiii., pl. ix., fig. 4.)

Colour, pale-green when laid, partly reddish to the naked eye, but salmon-colour under microscope in two days. Shape is longer then broad, small end rounded, broad end rather flat, transverse section almost circular. The whole shell is covered with hexagonal cells. The ovum is laid on its side. The larva emerges at the broader end.

Deposited on the 2nd December, 1900; hatched on the 16th December, 1900—fourteen days.

The young larvæ do not eat the empty eggshell.

Larva. (Vol. xxxiii., pl. ix., figs. 5, 6, 7, 8.)

Newly hatched. — Colour, pale yellowish-brown. The thoracic segments have thin red longitudinal lines; the incisions between abdominal segments 1 to 7 are ringed with red all round. The abdominal segments also have yellow spiracular and subspiracular lines running through the red rings.

The larva is robust, with uniform segments, but 7, 8, 9, and 10 are very crowded. The thoracic segments have legs;

the abdominal feet are midway between the 6th and 7th segments, and 10 has claspers.

The arrangement of the thoracic segments is not quite clear, but appears to agree with the structure in the second skin. The head has pointed hairs.

The abdominal tubercles have single setæ, which are club-tipped. Owing to the robust build of the segments the tubercles are very wide apart. The trapezoidals are normal. Supraspiracular and anterior subspiracular are both anterior to the spiracle and equidistant; post-spiracular moved up close to the spiracle. There are anterior and posterior subventral tubercles. The setæ on the abdominal feet are pointed. The larva-skin appears to be covered with very fine hairs.

Second Skin. — Larva attenuated, tubercles still widely separated. Head yellowish, spotted with red. From prothorax to anal segment yellow and red lines alternate longitudinally.

Head: Anterior hairs are pointed, posterior clubbed.

Prothorax: On each side of the thin median line of scutellum there are two anterior, two posterior, equidistant setæ. The prespiracular tubercle has a single seta. Above the spiracle, close to the scutellum, a very fine seta. The spiracle is posterior. Prespiracular tubercle has a single seta. Tubercle above the legs has two separate setæ.

Meso- and post-thorax: Close to the median line a minute normal tubercle bears a single seta, below this a larger tubercle and another (subdorsal); anterior and posterior tubercles are equidistant from the subdorsals beneath; the tubercle above legs bears one seta. All the tubercles bear only a single seta.

Abdominal segments have an additional tubercle below the spiracle. The spiracle is level with the posterior subspiracular tubercle. On the abdominal feet there are seven single setæ, and numerous setæ on claspers. Abdominal 9 has all the tubercles on the posterior edge; 10 has, above the anal orifice, two normal setæ, two pointed setæ on each side.

Full fed (30th January, 1901).—Length, $\frac{9}{16}$ in., wider at 5th abdominal, from which it tapers to head and to anus.

Colour: Brown, with mediodorsal pale line on the thoracic segments, represented on abdominals 1 to 5 by an inverted V —apex anterior, and line resumed but wider on the posterior subsegments of 6 to 9. The posterior trapezoidal setæ of 6th and 7th abdominals are on elevated humps; segment 8 has pale-coloured humps; 9 also has pale humps, but with a larger hump between them.

Laterally there is no definite marking, the whole skin being finely mottled brown and whitish. The setæ are all very

dark—black(?). The tubercle arrangement appears to exactly correspond with second skin.

In an earlier stage there is a lateral subspiracular and spiracular line in addition to the dorsal markings. The skin also has numerous white dots.

A slight cocoon is made on the top of earth.

On the 6th February, 1901, all had pupated.

Pupa. (Vol. xxxiii., pl. ix., fig. 22.)

Colour: Reddish; antennæ, leg-covers, &c., pale-brown, eye-covers dark-brown, wing-covers brown.

Length, $\frac{5}{16}$ in. From tip of head to tip of wing-cases is fully two-thirds total length of pupa, the posterior third constituting abdominal segments 5 to 10. Pupa is thickest at 1st, 2nd, and 3rd abdominals, and there is sharp irregular tapering from 7 to 10; 9 appears as a large swollen area overlying 10, which fits into it as if it were a cap, and terminates with two lateral, two central, hooks, with which a very firm hold is taken of the silk in the cocoon.

The eye-covers are large and prominent; antennæ extend to tips of wing-cases, enclosing legs and proboscis, which also extends to the tips of wing-cases.

Only the slightest portion of the base of hind-wing cases can be seen at the juncture with post-thorax. Spiracles on 1, 2, and 3 are subdorsal, 4 to 8 lateral. All the segments except 8 to 10 are deeply pitted.

Imagines emerged as follows: On the 25th February, a male; on the 26th February, a male and a female; on the 28th February, a male; on the 2nd March, a male; and on the 4th March, a female.

It is not my intention to discuss imaginal structures; indeed, this would not be in keeping with the title of my paper. What I have to say is rather in the nature of inquiry.

The larval antenna consists of a base, one or two joints, and appendages of a fleshy nature (Plate XIII., fig. 12). The imaginal antenna consists of scape (base), pedicel (2nd segment), and clavola (segments beyond). The scape is the muscular base and the pedicel is the nervous base, these being more or less simple in external structure (fig. 13). The clavola segments of *A. megaspilata*, male, have paired appendages attached to the shaft ventrally, and on this surface the segments are devoid of scales; dorsally the shaft is thickly protected with scales (figs. 14 and 15). The pectinations have no scales, but numerous fine hairs. The clavola segments act as sense-conductors.

The functions of the larval and imaginal antennæ are no doubt similar, and the homology of their respective parts should prove an interesting study. That such is possible is

suggested by the experiments of Dr. Chapman* on regeneration of the thoracic legs of *Liparis dispar*, which prove the homology of the larval and imaginal legs.

The marginal wing-bristles admit of further study (fig. 16). My note on those of *Melanippe fluctuata*† was, I understand, the first publication in England in reference to these. Dr. Chapman‡ has dealt with the same, but I have not yet seen his paper on the subject. Messrs. Furbush and Fernald had previously published observations on these structures in America. They are to be observed at the termination of the nervures, but are not of the nervures, since they occur at the wing-margin between the nervures. Professor Fernald believes they are found on the wings of all *Lepidoptera*. The function of the marginal wing-bristle is unknown.

EXPLANATION OF PLATE XIII.

Fig. 1. *Melanchra mutans*, micropylar area of ovum; × 200.
Fig. 2. " longitudinal ribs of ovum; × 200.
Fig. 3. " ovum; × 50.
Fig. 4. " ova from female abdomen; × 50.
Fig. 5. " larva, first skin, showing the imperfect development of abdominal feet.
Fig. 6. " larva, second skin, thoracic segments; × 200.
Fig. 7. " pupa, terminal armature; × 50.
Fig. 8. *Metacrias strategica*, larva, first skin, thoracic segments; × 200.
Fig. 9. " pupa, segments 5 to 10; × 50.
Fig. 10. " pupa, anal bristle; × 200.
Fig. 11. *Nyctemera annulata*, pupa, anal bristle; × 200.
Fig. 12. *Asaphodes megaspilata*, antenna of larva.
Fig. 13. " antenna of imago, scape, pedicel, first clavola segments; × 200.
Fig. 14. " antenna of imago, terminal clavola segments; × 200.
Fig. 15. " intermediate clavola segments; × 200.
Fig. 16. " marginal wing-bristles; × 200.

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* Entom. Record, vol. xii., 141.
† Entom., vol. xxxiv., 47.
‡ "Some Wing-structures," Trans. South London Nat. Hist. Society, 1900.

ART. XXVI.—*Notes on New Zealand Fishes.*

By Sir JAMES HECTOR, F.R.S.

[*Read before the Wellington Philosophical Society, 11th February, 1902.*]

Plates XIV. and XV.

1. **Chimæra monstrosa**, var. **australis.**

This remarkable fish is related to the sharks and the rays or skates, but is quite distinct from either of these groups. Only two generic forms are known—(1) *Chimæra*, which abounds in the Arctic seas; and (2) *Callorhynchus*, which, so far as known, is confined to the Antarctic seas.

In the northern seas this fish is known as the "king of the herrings," also as the "rabbit-fish." Its southern representative is popularly known as the "elephant-fish," on account of the proboscis-like appendage to its upper jaw. A few specimens of the northern genus *Chimæra* have been found off the Cape of Good Hope and off the coast of Chile, but so far as I know this is the first New Zealand example of the genus which has been found. It was obtained by the trawl on the Wairau bar, and presented to the Museum by Mr. Fernandos, of this city. The specimen is a female, both oviducts containing eggs in various stages of development. It is somewhat curious that the first specimen obtained in New Zealand should be a female, as the male fish is far more abundantly caught in the Northern Hemisphere than the female. In the case of the southern representative, or the elephant-fish, on the other hand, most of the specimens caught are females, and they are quite common at certain seasons. However, a few days after I obtained the female of the *Chimæra* a male elephant-fish was brought to the Museum, being the first of the sex I had ever seen. It has wonderful grippers armed with strong teeth on the forehead, and on each side of the body near the ventral fin, and has two extra lateral ventral fins involuted so as to form intromittent organs.

The following are the measurements of the female specimen of *Chimæra monstrosa*, var. *australis* :—

	Inches.
Total length	36
Greatest height	4
Snout to eye	2·5
Orbit	1·5
Snout to dorsal spine	6
Height of spine	3
Base of 1st dorsal	3·5

	Inches.
1st to 2nd dorsal, subcontinuous ...	3
Base of 2nd dorsal	16
Snout to mouth	2·5
Snout to pectoral	5
Base of pectoral	2
Branchial collar to vent	5·5
Snout to ventral fins	16
Pectoral fin, length	8
" width	4
" width at base of rays ...	2·5
Ventral fin, length	6
" width at base	2
Caudal fin	5
Filiform appendage	7

There are two genital orifices, one on each side and anterior to the vent, each with a distinct ovarian sac containing twelve to fifteen eggs in various stages of development, varying in size from a small pea to a nut. Each egg is enclosed in an elongated ovid membrane, the largest being on the right side 1·5 in. long.

Colour.—Olive-black above, silvery-white beneath the head, and dark-grey elsewhere. Head with small ocellated spots, and round the base of the dorsal five distinct white spots. As far back as the vent three rows of nine spots in each, and one broad but interrupted line of white. A pseudo-lateral line of forty-three pores marked by golden scales, which latter are also found on other parts. On the tail are thirteen bold white blotches, in continuation of the white lateral line on the body.

2. **Auchenopterus aysoni**, n. sp.

This elegant little fish is one of the blennies, a family fairly well represented in New Zealand waters, *Crysticeps australis* and *Trypterygium nigripenne* being close allies. Only one species of the genus is previously known, from the west coast of South America, but it differs in important respects from the specimen under consideration, which was presented to the Museum by Mr. Ayson, Inspector of Fisheries. Unfortunately, the spirit in which it was sent was too strong, so that the scales and many of the lateral pores were destroyed.

The following is a minute description of the fish:—

	Mm.
Total length, 5 in.	143
Height	30
Length of head	35
Base of 1st dorsal	12
Snout to 1st dorsal	10

	Mm.
Space of notch in dorsal	8
Continuous dorsal	80
To caudal	15
Extension of caudal rays	21
Snout to pectoral	23
" ventral	21
" vent	48
Length of pectoral	27
" ventral	20
Snout to eye	9
Diameter of eye	4

Fin Formula.—B., 4; D., 3–33; P., 8; V., 3 (but broken and indistinct); A., 10; LL., 22–3–5, interrupted.

Scales very minute.

Body compressed. Height one-quarter of length and one-sixth less than length of head.

Pair of branched tentacles from above the snout, not from the nostril.

Colour uniform light-brown, with four oval translucent spots on the dorsal fin.

Teeth minute on jaws and vorner.

Gill-opening wide.

Tail slightly unsymmetrical, and caudal distinctly separate from both dorsal and anal.

Loc. Bay of Islands; collected by Mr. Stephenson.

EXPLANATION OF PLATES XIV., XV.

PLATE XIV.

A. Female of *Callorhynchus antarcticus.*
B. Male of *Callorhynchus antarcticus.*
C. Female of *Chimæra colliei.*
D. Male of *Chimæra colliei,* L. (after Günther).

PLATE XV.

Auchenopterus aysoni.

ART. XXVII.—*On a New Polynoïd.*

By W. MALCOLM THOMSON, M.A.

[*Read before the Otago Institute, 8th October, 1901.*]

Polynoe comma, n. sp.

Body slender, long, linear, tapering slightly at the hinder end. Average length 50 mm., and breadth 6 mm. (spirit specimens).

Segments, 70–90; elytra, 35–45 pairs, borne on segments 2, 4, 5, 7, 9 and all subsequent odd segments.

Anus dorsal.

Prostomium embedded in the peristomium, urn-shaped, broadest between the eyes, slightly longer than broad, produced anteriorly into the bases of the lateral tentacles, between which the base of the median tentacle is wedged.

Eyes, two pairs, quite sessile and quite lateral, situated nearly at the point of greatest diameter. Median tentacle longer than the lateral ones, and longer than the prostomium. Palps about three times as long as the prostomium, stout at the base and tapering continuously to the tips, studded all over with minute spines.

Parapodia stout, conical, almost uniramous; dorsal chætæ few and extremely small, accompanied by a stout aciculum, tapering, serrated on each side, and ending in a fine needle-like tip. Ventral chætæ also few, but longer, fairly stout, and slightly hooked at the tip, which is blunt; provided with two asymmetrical spines on the dorsal surface, followed by two rows of four or five "combs" on each side.

Nephridial papillæ distinct, cylindrical, slightly fluted, beginning at the 10th or 11th segment and continuing to the penultimate segment; rendered conspicuous by segmental pigment patches near their bases.

Elytra subcircular; margin entire; surface smooth, except for a very few small tubercles on the first two or three pairs; pigment in the shape of a broad dark comma on the mediad moiety of the elytron. The first four or five pairs have a patch of russet-brown pigment on the convex shoulder of the comma-shaped mark; the first elytron is colourless but for this russet patch. The elytra of a side do not overlap in the hinder region of the body, but anteriorly they do. Only the first three or four pairs meet across the back. The rest of the back, being uncovered, exhibits dorsal bars of pigment at the back of each segment, which, well marked in front, vanish in the posterior region.

The ventral surface has a median and two lateral bands of dark pigment.

The worm was collected at Moeraki by Dr. Benham, of the Otago Museum, and all the specimens were found to be commensal with a Terebellid.

III.—BOTANY.

Art. XXVIII.—*A Short Account of the Plant-covering of Chatham Island.*

By L. Cockayne.

[*Read before the Philosophical Institute of Canterbury, 6th November, 1901.*]

Plates XVI.–XIX.

The group of islands and rocks known collectively as the "Chatham Islands" lies isolated in the South Pacific Ocean, at a distance of about four hundred and fifty miles east-south-east from the nearest point in New Zealand. It lies between the parallels 43° 30′ and 44° 30′ south latitude, and the meridians 175° 40′ and 177° 15′ west longitude. The largest member of the group—Chatham Island—is about thirty miles in length, and contains 222,490 acres. Pitt Island is next in size, with a length of barely eight miles and a half, and an area of about 15,000 acres. The only other islands sufficiently large to contain flowering-plants to any extent are Mangere and South-east Island, each of which is about a mile and a half in length. Pitt Island lies to the south of Chatham Island, from which it is separated by a narrow passage of water, about fourteen miles in width, called Pitt Strait. Mangere lies to the west and South-east Island to the south-east of Pitt Island, from which the former is distant a mile and a half and the latter a mile and a quarter.

The botanical history of the Chathams dates from the year 1840, when Dr. Dieffenbach visited the islands on behalf of the New Zealand Company, and made at the same time a small collection of the plants. These are recorded in the "Flora Novæ-Zelandiæ," and comprise only some twelve species of phanerogams and vascular cryptogams. For a space of eighteen years after Dr. Dieffenbach's visit nothing more was done botanically, when, a direct trade being established between Melbourne and the islands, a few plants were from time to time brought to Baron F. von Mueller, including the remarkable *Myosotidium nobile* (45, p. 2); but it was not until the year 1863 that the first real botanical exploration of the

islands was undertaken, when Mr. W. T. L. Travers, who previously had done so much to advance the knowledge of New Zealand botany, sent his son, Mr. H. H. Travers, to Chatham and Pitt Islands to make as complete a collection of the indigenous plants as possible. The expedition resulted in a very interesting collection of plants, from which Baron F. von Mueller compiled his well-known work "The Vegetation of the Chatham Islands." This was published in 1864, and contains descriptions or notes of 129 species of phanerogams and twenty-five species of ferns and lycopods, of which seven were species new to science. Had the distinguished author of the work not been a most staunch believer in the fixity of species (45, pp. 7 and 8), the number of species recorded would have been considerably larger, in proof of which statement it is only necessary to note his treatment of *Veronica*, *Calystegia*, *Epilobium*, and certain other genera.

In 1867 a paper appeared (24), written by Mr. Halse, which gives a most excellent idea of the general aspect of certain parts of the main island. Much more important, however, is the account of his journey in 1863 by Mr. H. H. Travers, published in the first volume of the "Transactions of the New Zealand Institute" in 1869 (51). In 1871 Mr. Travers paid a second visit to the islands, and his new collection added very considerably to the known number of their plants. Baron F. von Mueller contributed a short note on this collection to the "Transactions of the New Zealand Institute" (46), giving a list of certain genera* not collected during Mr. Travers's former visit.

In 1874 Mr. John Buchanan published a revised list of the flowering-plants and ferns of the Chatham Islands, based on the two collections of Travers (3), bringing the genera up to 129 and the species to 205, describing three new species and recording the occurrence of that very interesting restiaceous plant *Sporadanthus traversii*, now referred to the genus *Lepyrodia* (32, p. 969). Mr. Buchanan's list seemed at the time it was published to quite exhaust the possibilities of the Chathams as a field for new species, and so for many years Chatham Island botany appeared to be at a standstill. But during part of that time a most enthusiastic naturalist, Mr. F. A. D. Cox, who resides in Chatham Island, was collecting and studying its plants during his few intervals of leisure, so when the late Mr. T. Kirk sought aid with regard to Chatham Island plants, during the compilation of the "Students' Flora of New Zealand," Mr. Cox was very able and very willing to supply him with material, and, better still, with information

* In this list *Myosotis* is noted, so I was mistaken in writing of it as an unrecorded genus for the Chathams (11).

gathered at first hand from the plants themselves. In consequence of this valuable assistance Mr. Kirk treated the flora of the Chathams in a more searching and thorough manner than had been the case previously.

From the foregoing short history of the botany of the Chathams, it may readily be seen that botanists and collectors have been mainly concerned with the classification and finding of plants, and that very little indeed has been published regarding the plant-covering itself, the plant-formations, the conditions under which the members of the formations are living, the plant-forms which these conditions have evoked or preserved, the changes which civilised man has brought about in the vegetation, or many other matters of high œcological interest. It was with the intention of observing and studying such matters, and, above all, in the hope of being able to put on record a fairly accurate picture of a most remarkable vegetation, doomed in its primeval condition to extinction, that I paid a visit to Chatham Island at the beginning of this present year 1901. I stayed on the island during part of January and February, six weeks in all, but did not visit any of the other islands, so the details in this paper refer only to the vegetation of the principal member of the group, as notified in the title. I had not time to visit every part of the island. Details on this head are noted in the part of this paper dealing with the physiography; here it need only be mentioned that I camped for eleven days on the southern tableland, and was thus enabled to examine with some degree of care the vegetation of a portion of the island not previously visited by any botanist. And this was the more important since there alone may be seen tracts of country clothed with unaltered primeval vegetation, but which unique and interesting spots are every day becoming fewer in number and more limited in extent, so that without doubt in a year or two there will be no longer any virgin plant-formations on the island, except those of inaccessible rocks or of the larger pieces of water. As I write, Mr. W. Jacobs sends me word that the previously inaccessible forest lying under the precipitous cliffs of the south coast has been opened up to stock, and in consequence the last remnant of the Chatham Island forest will soon be a thing of the past so far as its primitive physiognomy is concerned.

Although Chatham Island is only small, its very irregular shape, the great lagoon which occupies its centre, and the difficult travelling through a vegetation sometimes extremely dense would require a much longer time than I was able to devote in order to make anything like an exhaustive examination of the plant-covering. This paper must be looked upon, then, as an introductory and most general one, and intended

merely to pave the way for much more thorough œcological investigations. I have purposely usually only treated with any detail those plants which are endemic, and in this case the sins of omission are many, while a too rapid examination of most of the formations has probably in some cases led to error.

Before concluding this introduction I must express my most hearty thanks to all those residing on Chatham Island with whom I came in contact. All sought to render me every assistance possible, and whatever success may have attended my visit is due principally to their great hospitality and extreme kindness. Also, I must specially express my great obligation to the following: Mr. F. A. D. Cox, Mr. A. Shand, Mr. E. R. Chudleigh, Mr. W. Jacobs, Captain F. W. Hutton, F.R.S., Mr. T. F. Cheeseman, F.L.S., Mr. D. Petrie, M.A., F.L.S., and Mr. H. Carse.

Physiography.

For the sake of convenience Chatham Island may be divided into three portions—a northern, a central, and a southern. The northern portion consists of two peninsulas, the western and the eastern, which are separated from one another by the northern and widest portion of Te Whanga Lagoon, and are connected only by the very narrow strip of land which in the north separates the lagoon from the ocean.

The western peninsula—Whareka on the map (49)—is about 16½ miles in length from Te Raki Point to Waipapa on the lagoon, and some seven miles broad at its base from the north of Waitangi Beach to the shore near Wharekauri. In the north two triangular pieces of land jut out northwards, culminating in Capes Young and Pattisson respectively. The eastern peninsula is a narrow triangular piece of land nearly nine miles and a half in length and five miles in width at the base, its widest portion. The northern portion of the great lagoon is eight miles and three-quarters in width, and is separated from the ocean by a narrow strip of land varying from a mile and a quarter in its widest to one-eighth of a mile in its narrowest part. The central portion of the island is occupied for a great part of its area by the southern part of Te Whanga Lagoon. This is separated from Hanson Bay on the east by a very narrow strip of land, varying from a mile and a half to a quarter of a mile in width; but on the west the land bounded by Petre Bay is of greater size and importance, having a width in the south of from two and a half to three miles and in the centre a mile and a half, while in the north a broad triangular piece of land stretches into the lagoon, measuring seven miles and a quarter from Karewa to the Waitangi Beach.

The south portion of the island forms a compact four-sided block of an almost uniform length of nine miles and a half from Petre Bay to Pitt Strait, and with a breadth of, from east to west, 13¼ miles. The south-east corner beyond Ouenga juts out slightly towards the east.

The greatest length of the island as a whole is thirty miles, measuring from Cape Young to Te Rahui, and its greatest breadth, measuring in the north from Te Whakaru Island to Te Raki, is thirty-five miles. From the above it may be seen that, owing to the peculiar shape of the island, no place in the interior is at any great distance from the sea or the great lagoon: in the north two miles and a half is the extreme limit, in the centre only one and a third miles, and in the more compact south four miles and three-quarters. Hence, no part of the island is beyond the reach and influence of a strong sea-breeze.

Speaking generally, the surface of the land is low, though in most places more or less undulating. The southern portion of Chatham Island is by far the highest above sea-level, and in comparison with the rest of the island looks quite hilly. Its highest portion, however, the Trig. station near Te Awatapu, is only 286 m., and Pipitarawai, the highest point of the main ridge and watershed of that part of the island, is about 2 m. lower. From this ridge to the sea stretches a kind of tableland, culminating in some abrupt cliffs, which vary in height from 182 m. to 213 m., and are cut in places into deep gorges by the small streams which drain the tableland. From the other sides of the Pipitarawai Ridge the land slopes gradually downwards to the coast. The flat but usually undulating surface of the northern and central portions of the island is relieved here and there by conical hills, which reach at times a height of 152 m. or 182 m., and of which the most important are the forest-clad Korako, Wharekauri, and Maunganui. The extensive coast-line varies in character from flat ground bordered with sandhills or low rocks to the high cliffs of the south coast. Small streams are abundant all over the island, but only two, the Waitangi and the Awainanga, rise to the dignity of rivers. Most of the streams flow slowly, and the water is always dark-brown, from the large amount of peat which it holds in suspension. The great lagoon, Te Whanga, is nearly fifteen miles in length, and its area is estimated at 46,000 acres (18). In certain places the lagoon is so shallow that it can be forded on horseback; indeed, under certain conditions of the wind the northern ford may be quite dry. Besides Te Whanga there are many other lagoons and lakes; indeed, it is stated that fully one-third of the surface of the island is occupied by water (18). Bogs of considerable size are very frequent, and occur both on the high and low ground.

Thus both the very low north-west of the island and the highest parts of the tableland of the south consist of quaking bog. Even when the ground is not boggy its water-content is usually very considerable; and, speaking generally for the whole island, excepting in places long cultivated, wet ground is much more common than dry.

The soil in most parts of Chatham Island consists of peat, which must in many places be of a very great depth, Mr. Travers stating that it is often 50 ft. deep (51). If the peat through any reason should become dry it will burn with great readiness, and should it be set on fire it may slowly burn for many years. Such burning—and it is perhaps from this that he gave his estimate of the depth of peat—is thus described by Mr. Travers (51, p. 177): "In several parts of the island this peat has been on fire for years, burning at a considerable depth below the surface, which, when sufficiently undermined, caves in and is consumed. I have seen the loose ashes arising from these fires upwards of 30 ft. deep." On the peaty plain on the north-west peninsula I saw a hollow caused by the peat having been burned, which even then was smouldering in places. This hollow was about 3 m. in depth—*i.e.*, only one-third of the depth stated by Mr. Travers—and its area about 2 acres. The burning must have taken place many years ago, for the bottom of the hole was a dense mass of vegetation, thus affording a very interesting example of what species of indigenous plants will, under present climatic conditions, people a piece of virgin ground. Very often these burnt-out hollows become filled with water and remain as permanent lakes; indeed, Mr. A. Shand is of opinion that probably all the lakes of the island, including even those of the tableland, have originated recently in this manner. Besides peat, a much richer soil, called locally "red clay" and formed of disintegrated volcanic rock, occurs in some few places—much of the country from the south of Lake Huro to the Whanga Lagoon and for some distance further south-east is of this character; other patches occur from the Ngaio to Waitangi along the coast, and others again in the neighbourhood of some of the old volcanic conical hills.

As pointed out in the introduction, I did not visit quite a number of important localities. Of these the chief were the extremity of the north-western peninsula, from Maunganui to Te Raki Point; the south coast of the north-western peninsula; the narrow slip of land along the north coast from Wharekauri to Matarakau; the east coast of the island from the ford over Te Whanga to Ouenga; and the greater part of the coast-line on the east from Waitangi to the Horns.

GEOLOGY.

Not very much is known about the geology of Chatham Island. Mr. Travers collected rock specimens and a few fossils. From these specimens and from notes supplied by Mr. Travers Sir Julius von Haast published the only paper (a very short one, occupying a page and a half) which, so far as I am aware, has appeared on the geology of the island.* Captain F. W. Hutton, F.R.S., has also examined Mr. Travers's specimens, and he tells me that he agrees with the main conclusions in Haast's paper—namely, that the Chatham Islands first emerged from the ocean during some portion of the Tertiary period.

The following is abstracted from Haast's paper (23): "The principal island is of volcanic origin, and consists chiefly of basaltic and doleritic rocks and tufas." "Several cones with a crater-like character show in the different centres of eruption, whilst around them and extending from one to the other marine sands have formed barriers enclosing tracts of low land favourable for the formation of peat swamps." I may here point out that, as probably the islands have extended over a much wider area than is now the case, these sand barriers must be of comparatively recent origin, while also these tracts of low land are in the north and not in the south of the island, which also contains most extensive deposits of peat. "The oldest rocks visible occur near Kaingaroa, and consist of micaceous clay slates, silky and of a pale-grey colour." These rocks, Captain Hutton tells me, must be a portion of an ancient rocky platform from which the new volcanic islands arose. "Some beds of limestone fringe the south-western shores of that lagoon"—Te Whanga. Haast concludes, "Thus clear evidence is offered to us that in an early part of the Tertiary period volcanic action took place in this part of the Pacific Ocean, and, although we meet on the main island some signs of the existence of old sedimentary rocks, there is no doubt that these volcanic eruptions gave birth to this archipelago." Haast also mentions the occurrence of lignite beds overlaid by limestone on Pitt Island, and Mr. Florence (18) calls attention to the occurrence of lignite in the north of Chatham Island.

CLIMATE.

Meteorological observations have been taken for a number of years by Messrs. Shand and Cox in the neighbourhood of Waitangi, the thermometers being kept in a screen standing on the grassy slope facing south-east in front of Mr. Cox's

* See Trans. N.Z. Inst., vol. ii., art. xliii.: "Notes on the Geology of the Outlying Islands of New Zealand" (including Chatham Islands), p. 183, by J. Hector.—[ED.]

residence. This locality is about 30 m. above sea-level. In an area so small as Chatham Island, where every part is within a few miles of the sea, and where the highest land only attains a height of 286 m., it seems unlikely that there should be any marked differences in temperature or rainfall; but Mr. W. Jacobs, who is intimately acquainted with the high southern portion of the island, assures me that there the rainfall is greater and the cold more severe than in the neighbourhood of Waitangi. With regard to differences in temperature, I think he is mistaken; but, as for the rainfall, my own very limited experience goes to confirm his statement. Mr. Cox also writes to me of the greater rainfall in the neighbourhood of Pipitarawai as if it were a well-known fact.

The average rainfall at the meteorological station is 30·4 in. (18). This is by no means high when compared with many places in New Zealand, but the number of rainy days is considerable. For example, 28·32 in. of rain fell on 192 days in 1890; 34·46 in. fell on 187 days in 1899; 24·29 in. on 185 days in 1897; 32·17 in. on 194 days in 1896; 34·48 in. on 194 days in 1895; and 35·01 in. on 190 days in 1894. Thus light showers, very often of short duration, are frequent, while heavy rain is exceptional, although there is usually at least one fall during the year of from 1 in. to 2 in. or even more during the twenty-four hours. The rain usually comes from the north, consequently it is a warm rain; but, as is so often the case in many parts of New Zealand, this is immediately followed by much colder rain from the south-west, which has a direct effect on restraining vegetable growth. The driest month is December, with an average rainfall of 1·67 in., while the wettest is July, with an average of 3·92. Taking the seasons of the year, summer is the driest and winter the wettest, the figures being: Spring (September, October, November), 6·11 in.; summer (December, January, February), 5·97 in.; autumn (March, April, May), 7·76 in.; and winter (June, July, August), 8·83 in. The character of the vegetation of any region depending more upon the number of rainy days than upon the total rainfall, the average number of rainy days for each month of the year is of special interest; these are: January, 11·7; February, 11; March, 12·1; April, 13·7; May, 17·8; June, 19; July, 23·2; August, 18·2; September, 16·8; October, 17·7; November, 14·7; December, 10·9.

Turning now to the temperature, the mean yearly temperature is 51·4° Fahr., and the mean daily range 10·4° Fahr. The extreme maximum and minimum temperatures for each month are respectively: January, 73° Fahr., 35° Fahr.; February, 70° Fahr., 35° Fahr.; March, 69° Fahr., 40° Fahr.; April, 67° Fahr., 37° Fahr.; May, 64° Fahr., 34° Fahr.; June,

58° Fahr., 32° Fahr.; July, 59° Fahr., 31° Fahr.; August, 58° Fahr., 30° Fahr.; September, 59° Fahr., 31° Fahr.; October, 60° Fahr., 34° Fahr.; November, 67° Fahr., 36° Fahr.; December, 74° Fahr., 38° Fahr. The mean daily maximum temperature for a series of years ranged between 67° Fahr. and 60° Fahr. for January, the hottest month, and between 51·6° Fahr. and 48·8° Fahr. for July, the coldest month; similarly, the mean daily minimum ranged between 56·3° Fahr. and 48·6° Fahr. for January and 42·6° Fahr. and 38·2° Fahr. for July. Such figures as the above are of very little value in estimating the degree of heat to which the plants are subjected, since the readings were taken in the shade. On this point Mr. T. H. Kearney writes, in a recent work on the vegetation of a certain island near the coast of the United States (34, p. 262): "Readings were taken in the shade, consequently they do not represent the temperature to which most of the vegetation is actually exposed, being subject to insolation during the hours of sunshine; they are chiefly valuable for purposes of comparison with other climates." Although the thermometer very frequently falls below 40° Fahr. in Chatham Island, owing chiefly to the frequency of the cold south-west wind, it rarely reaches the freezing-point. The frost never exceeds 1° or 2°, or perhaps double this amount on the ground; while not unfrequently there is no frost at all during the year. Some years are quite without snow, in others snow has fallen on one or two days; but it usually melts as it falls, and never lies on the ground for more than a few hours. Associated with the frequent showers is a cloudy sky, and mists are not uncommon, especially in the early hours of the morning. The average number of calm days during the year is only seven. This fact speaks volumes as to the importance of the wind factor on the plant-life of Chatham Island. The most important winds are the rain-bringing north-west and south-west winds; if to the former are added those marked "N." in the statistics and to the latter those marked "S.," the average number of days on which it blows from north-west to north are 116·3, and on which it blows from south-west to south are 139. Taking the east, south-east, and north-east winds together, these blow on an average on 71·1 days, while the west wind blows on 28·3 days.

Speaking generally regarding the climate of Chatham Island, as shown by the above figures and others in the statistics not quoted here, also from information given to me both by Messrs. Cox and Shand, the climate is exceedingly mild and equable—the summers are never very hot, while in winter there is occasionally a very slight frost. Light showers, lasting only a very short time, are frequent. The

sky is often cloudy, and mist accompanies the northerly winds, especially in spring. The winter is the wettest season of the year, and in consequence of the wet nature of the ground, even in dry weather, much water lies about in flat places and hollows during that season. The wind is always blowing from some quarter or another, and often with considerable violence. The air, in part owing to the wet nature of the ground, must contain a great deal of moisture. Thunder-storms occur occasionally, after which there is nearly always a week or more of unsettled weather.

A good deal can be learnt about the climate of any district by observing the plants which are cultivated in gardens or fields. In Chatham Island all the ordinary vegetables grow very well indeed; potatoes especially succeed so well that in the early days they were to some extent a source of revenue. The first early potatoes are dug at the end of October or the beginning of November. Cereals are not much cultivated, oats alone being grown to any extent. These are sown in August or September and reaped in February, yielding, when grown on good ground, 40 or 50 bushels to the acre. Wheat is not now grown; neither the climate nor the soil is especially suitable, but probably the chief reason for its exclusion is that flour can be more cheaply imported than produced on the island. Certain plants growing in Mr. Cox's garden testify to the mildness of the climate. Amongst these are greenhouse *Pelargoniums* forming large bushes, greenhouse *Fuchsias* of a similar size, *Sempervivum arboreum*, and an arborescent species of *Aloe* not hardy in Canterbury gardens. Growing side by side with the above are most of the indigenous *Olearias* and *Veronicas*, two or three species of New Zealand subalpine *Veronicas*, and a most magnificent specimen of *Olearia lyallii* from the Snares, a plant very difficult to cultivate in many parts of New Zealand. All the ordinary hardy fruit-trees thrive and bear fruit abundantly. At Te Whakaru, only a few metres above high-water mark, is one of the orchards planted more than fifty years ago by the missionaries. The trees at the time of my visit were almost breaking under the weight of fruit. But the most interesting fact about this orchard is that it is quite free from all those kinds of animal and vegetable pests now so common on New Zealand fruit-trees.

History of Man on Chatham Island.

The influence of man through the disturbing factors, which in direct proportion to his degree of civilisation he has introduced into the vegetation of all inhabited lands, is a matter of very great interest and importance. It therefore seems necessary, before discussing the plant-formations in detail, to give

some account of man's history on Chatham Island, so that it can be seen what new factors he has added to the surroundings of the vegetation, and for how long a time they have been influential and to what degree of power they have attained. Then, having pictured as accurately as my limited investigations allow the primeval plant-covering in its various phases, an attempt is made to pourtray the changes in that vegetation which man purposely or accidentally, by means of cultivation, animals, exotic plants, and fires, has brought about. All this is the more interesting since it seems to me that but the merest fraction of the vegetation of civilised or semi-civilised portions of the Old World can be in its primeval condition*—that, for example, forests, and even alpine meadows, which appear to all intents and purposes primeval are but artificial productions after all. But the vegetation of Chatham Island has, ever since it first became isolated on that land, been, prior to the advent of man, exposed to no foreign influences, not even to those attacks of wild herbivorous mammals under the modifying influence of which much of the vegetation of the earth has been developed.

The aborigines of Chatham Island are Polynesians, and appear to be merely a branch of the Maori race. According to Mr. A. Shand they, before the arrival of any other people, had lived on Chatham Island for about seven hundred and seventy years. They did not cultivate the ground at all. The only vegetable foods they made use of were the rhizome of *Pteris esculenta* and the fruit of *Corynocarpus lævigata*. Their settlements were not confined to any one part of the island, but they moved about here and there according to plentifulness of food in certain localities. When the sea-birds came to lay their eggs on the "clears"† in the south of the island they would live in that part. So important was this article of food to them that they made a sort of rude calendar based on the period when any particular egg was most abundant. The egg season over, they would move about the rocky portion of the coast for fish, along the lakes and lagoons for eels, or they would visit those places where the holes of the mutton-birds most abounded; even they would visit in their large canoes the neighbouring islands and rocks in search of birds. All the above would have little effect on the vegetation. The dense

* Mr. W. L. Bray writes regarding the vegetation of western Texas (2, 118): "Under what may be called natural conditions to distinguish them from conditions which prevail under the present era of exploitation the grass-formations held their own in the perpetual struggle against woody vegetation. With the advent of the cattle business, however, this advantage was lost, and the present is an era of the rapid encroachment of timber-formations."

† The name "clears" is given by the white settlers to those places not covered with forest.

forests and bogs the Morioris would avoid, and foot-tracks would come to be formed over the easiest ground, which are possibly identical with the main tracks through the island at the present day. The only way in which they could do any damage to the plant-covering would be through setting the swamp and dry ridge vegetation on fire, for the forest, happily, will not burn; and probably some of the present lakes originated in that manner, through the peat catching fire during the Moriori period.

In November, 1791, Lieutenant Broughton, Commander of H.M.S. "Chatham" (47), discovered Chatham Island. He sailed along the north coast, landing in the neighbourhood of Kaingaroa. There he hoisted the British flag and took possession of the island in the name of King George III. While on shore he had an encounter with the natives and one was killed.

No more white men visited the island until 1834, when a Sydney whaling-ship arrived, which had on board four young Maori sailors. Probably the captain of this ship, or of some of the other whalers which about this time visited the island, introduced the pig; at any rate, in the early "fifties" these animals were more numerous in a wild state than they are at the present time. The four Maoris brought the tidings to their tribe of the excellence of Chatham Island, and, as it offered a haven of refuge from Te Rauparaha, the whole tribe decided to leave New Zealand and settle on the island. Accordingly, in 1835, they seized a vessel and compelled the captain to take them from Wellington to Chatham Island. Two trips were made to the island, and about nine hundred Maoris were landed on its shores. The Morioris, the number of whom has been estimated at from fifteen hundred to two thousand, being essentially a most peaceful race, and in consequence of their isolated position knowing nothing of the art of war, were quickly subdued and reduced to a state of slavery by the invading Maoris, who, moreover, were armed with firearms. The Morioris rapidly decreased in numbers, some hundreds being soon killed by the Maoris. Famine and disease also decimated them, and so they have decreased year by year until now less than a dozen pure Morioris are in existence. The Maoris brought with them potatoes, taro, and kumaras, but found the climate suitable only for the potato, which they cultivated in sufficient quantities to supply their wants.

In the year 1843 five German missionaries, of whom one, Mr. Engst, is still alive, and resided on the island till quite recently, were sent from Berlin by a German missionary society, and with their advent must date the first beginnings of change in the vegetation, for they made gardens, cultivated wheat to

some extent, and a little later on planted orchards. With the fruit-trees came over a grass, Mr. Shand informs me. This I have not seen, but it was probably one of the first introduced plants to spread spontaneously on the island. As the fruit-trees would not grow without shelter, the missionaries made use of the indigenous *Olearia traversii* for this purpose, and it answered admirably.

The most important event for the future of the vegetation was the introduction of sheep, cattle, and horses. In 1841 Mr. Hanson, who had visited Chatham Island on behalf of the New Zealand Company, sent a few cows and a bull to be pastured on the island. At a later date most of these cattle and their offspring were removed to New Zealand, but a few were secured by the missionaries. Shortly afterwards a few merino sheep were brought to the island, but they did not evidently increase to any great extent, for in 1855 there were probably only about two hundred sheep on the island, and these mainly in the neighbourhood of Ouenga. At a little later date than the cattle and sheep, horses were introduced, but for a long time they were scarce, and it was not until the year 1868 that they became wild in the unsettled districts. Cattle must have become wild much earlier, for Mr. Shand tells me that traps were made for them in the early part of the "sixties," and at the present time they are very numerous indeed on the table-land. It was not until the year 1866 that sheep-stations were organized as at present, at which time there would be perhaps two thousand sheep on the island. Since the above date sheep, horses, and cattle have increased enormously, horses as well as cattle being wild in many places and in considerable numbers, while some sixty thousand sheep roam over the whole of the island.

In addition to the animals many exotic plants have come over in the train of the white man, every one of which, when once established, must play a part in altering the aspect of the different plant-formations of which it is able to become a member.

The direct influence of the white man on the vegetation has not been very great, cultivation not having been undertaken on a very large scale.

Plant-formations.

In an island so small as Chatham Island, where herbivorous animals have roamed almost everywhere at their own sweet will ever since their first introduction, and where, moreover, much of the vegetation has been burnt again and again, hardly any of the plant-covering can still be in its virgin condition. On this account the plant-formations may be divided into the recent, or modified, and the original, or

unmodified. From a careful study of the present plant-covering in a large number of places it seems certainly possible in many instances to get a fairly accurate idea of the original formations, especially when aided by the information of those who have resided on the island almost from its first settlement by Europeans. Those small pieces of original vegetation which from their peculiar situation have up to the present been undisturbed also aid most notably in affording a clue to the character of similar formations in other parts of the island; but, of course, the results deduced from such a comparison must be accepted with caution, since a slight difference in edaphic conditions may lead to more or less considerable changes in a formation. In some instances the descriptions of the individual plant-formations which follow are limited to certain stated localities.

Dr. H. C. Cowles very justly observes (14[2], p. 178) that "plant societies must be grouped according to origins and relationships, and the idea of constant change must be strongly emphasized"; and, further, "The laws that govern changes are mainly physiographic; whether we have broad flood plains, xerophytic hills, or undrained swamps depends on the past and present of the ever-changing topography." The above ideas I have attempted to in some small degree carry out, and have taken for the most part the plant-formations in what seems to me their order of sequence, and have sought in some instances to point out their relationships. To have attempted, however, a physiographical classification of the formations with any degree of thoroughness was out of the question. Such would require, in the first place, to be based on what does not yet exist—a description of the topographical geology of the island by a competent geologist; and, in the second place, a very much more accurate study of the formations than I was able to make would be essential.

There are on Chatham Island two distinct regions of vegetation, of which the most marked difference is shown by the forests. The one is confined to the tableland, and the other comprises all the remainder of the island. For this latter I suggest the name "lowland region," a not particularly good name, but sufficiently applicable, since most of its surface is only a few metres above sea-level, while its hills are low isolated volcanic cones. Probably some of the differences between the vegetation of the tableland and lowland regions have been accentuated by fires, &c., while the woods above the north-west and west coast of the southern part of the island seem, so far as a rapid examination showed, to be in some degree a transition between lowland and tableland forest. All the same, the differences between the

vegetation of the two regions is sufficiently well marked, and that such should occur on two adjacent parts of a very small island is a matter of considerable interest.

Sandy Sea-shore.

The only portion of this formation examined with any degree of care was the shore in the north of the island, stretching from Wharekauri to Cape Young. Here the shore gradually merges into the dunes by way of very low mounds and ridges. The conditions for vegetation establishing itself and thriving in such a position are very severe, owing to the looseness and dryness of the soil, exposure to frequent sea-breezes causing drifting of the sand and excessive transpiration from the leaves of the plants, liability to submersion by salt water at periods of abnormally high tides, more or less salt in the soil at all times, and strong insolation. The sand is rather coarse in texture—much more so, indeed, than in some other parts of the island (Waitangi Beach, *e.g.*)—and contains an abundance of very small pieces of minute shells. Just above high-water mark grow *Calystegia** *soldanella* and *Ranunculus acaulis* in patches here and there, but forming only a very thin covering on the loose and easily moved sand. The trailing stems of *C. soldanella*, furnished with a few fleshy leaves, are very short, being rarely more than 4 cm. in length; the rest of the plant is subterranean, with the exception of the flowers. These latter are large, lilac and white in colour, semiprostrate, with their peduncles buried beneath the sand right to the base of the calyx. This small development of *Calystegia* contrasts greatly with the same species when growing on sand-dunes at some distance from the sea in many parts of New Zealand. There it forms great masses trailing over the sand, or, when growing in sheltered positions amongst other plants, it actually assumes a climbing habit of growth. *Ranunculus acaulis* grows in small rosettes, connected together by white underground stems. The leaves, of which there are four or five in each rosette, lie flat on the sand, are ternate in shape, of a rather thick texture, and varnished on the upper surface. The roots are fleshy, seven or eight times as long as the leaves, and descend deeply into the sand. The flower-stem, by the time the fruit is mature, usually arches downwards towards the ground, thus often depositing the ripe achenes below the surface of the sand. This may be merely the result of a mechanical bending of the

* This Hooker (29, p. 198) considered identical with the European and Australian forms of this species, but, as he held the opinion then so prevalent that species were large conjunctive groups, it may quite well be that the New Zealand plant differs from the European, or even the Australian, in certain particulars.

stem by the drifting sand aided by the increasing weight of the fruit, or it may be an adaptation for sowing the seed, thus hindering it from being blown inland into positions where the seedlings would have little chance of maintaining themselves amongst a more luxuriant vegetation. Whether such bending of the stem is hereditary can only be ascertained by experimental culture.

The sandy shore plant-formation is distinctly a modified one, though to the casual observer there is nothing to notify that fact. In its primitive state it might well have received the name of "*Myosotidium* formation." Just* above high-water mark, where the great masses of kelp accumulate, right up to the junction of shore and dune, on to the dunes themselves, and into the open part of the *Myrsine-Olearia* "scrub," formerly extended great clumps and patches of this truly magnificent plant. Not only on the sandy shore was it found, but it occupied low peaty ground near the sea, rocky shores, and rocky ledges of cliffs covered with sand, where, with the immense sow-thistle, it must have struggled for sovereignty. At the present time, as explained further on, it is hardly to be found wild in the island. *Myosotidium nobile* has a stout rhizome creeping either just below the surface of the ground or often with its greater part above the surface, in the manner of the New Zealand *Ranunculus lyallii* or the Californian *Saxifraga peltata*. Such a rhizome in a wild plant which I examined measured 5·2 cm. in diameter. The leaves in shape and form are not unlike those of the garden rhubarb, and consist of a comparatively thin lamina held in position by an extremely strong framework of midrib and veins beneath, and the course of which is defined by channels on the upper surface. The leaves are nearly always bent in the form of a funnel, which must be very advantageous for catching the water of the light showers and conducting it to the channelled petiole, flowing down which it reaches the roots. Petioles, midribs, and veins are very fleshy and juicy. Certain leaves which I measured were 25 cm. by 29·5 cm.; 27 cm. by 22 cm., with petiole 12 cm.; 32 cm. by 38 cm., with petiole 44 cm. The large leaves, after being cast off, very soon become dry, and in course of time a very considerable depth of humus results. The peduncles are stout, and raise the flowers above the foliage. In one case a peduncle measured was 60 cm. tall and 18 mm. in diameter, bearing a close head of racemes 12 cm. in diameter. The central half of the corolla is bright blue, changing afterwards to purple, and the outer half is white. Mrs. Chudleigh, of Wharekauri, discovered a form with white

* According to Mr. F. A. D. Cox.

flowers some years ago, and through her instrumentality this has become fairly common in cultivation. There is a notion prevalent that *M. nobile* cannot be grown inland at any distance from the sea, Mr. A. Bathgate, *e.g.*, stating that it requires the salt air (1^1), but this is quite a mistake. One of the finest plants I ever saw in cultivation was shown to me by Mr. T. W. Adams in a garden situated at Greendale, on the Canterbury Plains, at a distance of twenty-four miles from the sea, the plant in question having been there for more than ten years, flowering regularly and bearing abundance of seed. It seems to me that most likely *M. nobile* has been thrust into its present maritime position not by choice, but by the pressure of encroaching plants or other enemies. M. Battandier, as the result of eleven years' close study of the flora of Algeria, has come to a similar conclusion with regard to certain maritime plants, and in a most interesting paper details the facts on which his opinion is based (1).

Sand-dunes.

Sand-dunes of considerable extent and varying height occupy a large proportion of the ground adjacent to the sea. They extend along the whole east coast from Te Whakaru in the north to Ouenga in the south, along most of the north coast from Kaingaroa to Waitangi West, and along a very large part of the coast of Petre Bay in the west. Before the introduction of herbivorous animals these dunes were covered in many places with a dense forest, consisting chiefly of *Olearia traversii* and *Myrsine chathamica*, and reaching in many places almost to the water's edge. At that time moving sand-dunes may have been unknown. But now there is a very different state of affairs. True, the forest still fringes the coast-line in many places, but here and there it is broken through by great hills of drifting sand, which have buried wholly or in part the former plant-covering. Such moving hills have in some instances passed beyond the limits of the former wooded area, and are encroaching rapidly on the inland meadow land. A striking example of this encroaching sand burying the forest may be observed between Waitangi and Te One. There in places tree-tops project from the summit of the highest dunes. In one spot on the landward side on the flat is a grove of *Olearia traversii* where every stage of burial can be observed, from the tree-tops almost covered, to their bases just covered by the sand. This advance landwards of the sand is very serious from the economic point of view; but happily the settlers have found a remedy within recent years in the planting of marram-grass on the moving dunes. This, as might be expected from the results of planting this grass in other countries, has proved a

very great success, and now, where but three or four years ago was a desert of sand, tall grass may be seen waving in the breeze, each clump so close to the next that no sand is visible. Nor need a grass little relished by stock be alone made use of. *Elymus arenarius* has also been planted, and thrives equally well, and Mr. J. Barker tells me that at Kaingaroa stock eat it with avidity.* Although the sand-dune vegetation has been much changed by the advent of domestic animals, it is possible to get a fairly good idea of what it was like in its original state by examining, in as many localities as possible, those portions which have been the least changed. The dunes abutting on that part of the Wharekauri Beach the plant-covering of which has been described above are well adapted for the purpose in view, insomuch as they are still covered with vegetation almost to high-water mark, the forest forming a wide belt, separated from the sea-shore by a narrow zone, only a few inches in width, of stable dunes covered with certain characteristic sand-dune plants of more lowly growth. And this locality also affords a striking example of the different stages in the evolution of the vegetation of a sandy coast, commencing with the more or less open vegetation of the strand, and passing by way of low dunes fixed by various sand-binding plants to the final higher dunes covered with forest.

Commencing at the junction of shore and dune, the sand at first forms merely low mounds or ridges. The vegetation, though fairly abundant for a medium such as sand, is open, many places being quite bare. On the ridges grows the common New Zealand grass *Festuca littoralis*. This grass casts its "seeds"† in large masses alongside the parent plant, where, being soon buried by the drifting sand, they readily germinate. Behind the *Festuca* are higher mounds clothed with *Pimelea arenaria*, the long cord-like underground stems of which put forth adventitious roots near their extremities, which latter, bending upwards, raise themselves above the encroaching sand. The leaves are closely imbricating near the extremities of the branches, but below are a little more open. They are all most densely silky on the under-surface, a most efficient protection against excessive transpiration. Owing to the leafy extremities of the stems being erect,

* Other plants used for binding sand with success in Europe are *Ammophila baltica*, *Calamagrostis epigea*, *Carex arenaria*, and with these are used various species of *Pinus*, *Picea*, *Betula*, and *Alnus*. (See "Handbuch des deutschen Dunenbaues," P. Gerhardt, Berlin, 1900.)

† For the sake of convenience, the term "seed" is used throughout this paper in its popular acceptation, and includes, of course, various kinds of fruits.

the semi-rosettes of leaves can receive the incident light to the best advantage. Below, the stems are marked faintly with the old leaf-scars, thus defining those portions of the plant which have formerly been terminal. It is probable that the oldest portions of the plant—*i.e.*, the most deeply buried portions—die, while the plant continues to increase by the rooting of its terminal shoots. Such a plant might, then, attain to a very great age, so long as it was able to hold its own against advancing sand or denuding wind. The *Pimelea* mounds are from 1 m. to 1·2 m. in height. Sometimes the *Pimelea* grows unmixed with other vegetation, but more often its protection is taken advantage of by other plants, especially by *Deyeuxia billardieri*, *Isolepis nodosa*, and *Acæna novæ-zelandiæ*. Such a plant of *Pimelea arenaria* as described above averages about 4 m. in length, 3 m. in breadth, and 47 cm. in height. Another abundant plant of this zone is *Carex pumila*, which here grows in association with *Convolvulus soldanella*. This *Carex* has also the power of growing upwards as the sand covers it, and, with its stout, long, creeping rhizomes, assists the dune very materially in resisting the wind and the advancing sand. *Ranunculus acaulis* is also abundant here, playing its part as a sand-binder, and in habit much the same as described before when treating of the strand vegetation. Less abundant than any of the foregoing is *Euphorbia glauca*, which forms small colonies extending sometimes into the more open parts of the adjacent forest. Its seedlings are fairly plentiful on the sand near the parent plants. Although not very abundant on that part of the dunes here treated of, *Scirpus frondosus* is by far the most characteristic sand-dune plant of the island, and, indeed, of the whole New Zealand area. It can form settlements and hold its own in positions where no other New Zealand flowering-plant can exist, and only the most constant and furious winds can destroy a dune where it is properly established. Indeed, for sand-binding power it is probably not equalled either by *Ammophila arenaria* or by *Elymus arenarius*.

The sand-dunes bearing the forest zone are higher than those just described, and extend inland for a distance of 300 m., more or less. The plant-covering consists near the sea entirely of *Olearia traversii* and *Myrsine chathamica*; further inland other trees put in an appearance. *O. traversii* always maintains its character as a low tree, but *M. chathamica* loses altogether its tree-like habit as it nears high-water mark, and under the influence of the numerous and sometimes violent sea-breezes becomes a leafy shrub with dense close branches. The difference in appearance between the two forms of this plant is so great that one might very easily mistake them for two distinct plants.

Originally such dune forests* must have been very dense; even now the trees are quite close in many places. On the dunes facing Petre Bay in more than one locality the liane *Muhlenbeckia adpressa* may be seen climbing over the *Olearias*, with its numerous interlacing, bare, rope-like stems.

Compared with the sand-dunes of most parts of New Zealand† a marked difference lies in the extreme closeness with which the arborescent vegetation of the Chatham Island dunes approaches the shore. This has been brought about, I should imagine, by the general moisture of the atmosphere, the extremely equable climate, and the freedom from periods of drought. In such a climate as this, as long as the dunes are stable, there is little hindrance to trees, especially those of xerophytic habit, establishing themselves and driving the original sand-fixing vegetation towards the sea into an ever-decreasing area, until finally such plants, with their special adaptations against drought and salt in the soil on the one hand and instability of the substratum on the other, would be confined to the narrow zone where in the least changed portions of the sand-dune formation they are now to be found. Moreover, the sand usually, or perhaps always, overlies a layer of peat, and this will be of great benefit for tree-growth. As an example of how a sand-dune forest might originate, my notes furnish the following clue: "On the sand-dunes between Waitangi and Te One *Pimelea arenaria* occurs in large quantities, forming fixed dunes. Where this plant has quite conquered the drifting sand"—this is, of course, recent drifting sand caused by the destruction of the original vegetation by cattle and sheep—"it encourages the growth of other plants—*e.g.*, *Acæna*, *Gnaphalium luteo-album*, and even young seedling plants of *Olearia traversii*." With no enemy to trample it down or feed upon it, and under the shade of the *Pimelea*, *O. traversii*, thanks to its rapid growth, would soon be well established, and with its enormous number of "seeds" and their extreme suitability for wind dissemination, to say nothing of its xerophytic structure, young plants would soon be established in all favourable localities. *Olearia traversii*, as it occurs on the dunes, is a low tree, with a rather dense head of foliage and a bare trunk covered with rough bark. The leaves are 5·5 cm. long by 2·5 cm. broad, or shorter and narrower. They are rather thick but soft, of a bright shining-green on the upper surface and with the under-surface clothed with extremely dense

* The more inland part of the dune forests are treated of under the heading "Lowland Forest."

† For an account of certain sand-dunes in the North Island of New Zealand, see Cheeseman (Trans. N.Z. Inst., vol. xxix., p. 364).

white tomentum, as are also the short petioles and ultimate branchlets. The epidermis is two-layered, and the vascular bundles are surrounded by a sheath of stereome.

Probably *Sonchus grandifolius* originally grew in some abundance on the fixed dunes, but at present it is to be found only in a few places. *Tetragonia trigyna* also must at one time have been more or less common. In one place on the inland side of the dunes, near Lake Te Roto, I noticed a few plants of *Dodonæa viscosa*.

Sand-covered Ledges on Rock.

Closely related to the sand-dunes are those flat places and ledges on maritime rocks on to which sand has blown. Red Bluff, on the west coast of Chatham Island, furnishes a good example of the vegetation of such stations. There, just above high-water mark, *Sonchus grandifolius* grows with great luxuriance, its large fleshy leaves pressed closely against the sand. This plant is furnished with a very thick juicy creeping rhizome. The leaves are of very great size, but unfortunately I had no measure with me at the time of observation. According to Mr. T. Kirk (37), they are "from 1 ft. to 2 ft. long by 4 in. to 7 in. broad." The plant is truly a herbaceous one, its aerial portion dying down to the ground every year—an uncommon phenomenon with the plants of New Zealand generally. The young leaves make their appearance in September, and grow with considerable rapidity. The mature leaves are thick and rather hard. The pale-green upper surface is slighty concave, owing to the leaf-segments being bent upwards; the under-surface is glaucous, probably owing to a covering of wax. The florets are pale-purple towards the circumference of the head, assuming a lighter colour toward the centre, where finally they are pale-yellow. The under-surface of the florets is dark-purple near the apex. The outer involucral bracts are extremely thick, and armed with short thick spines. Such spiny bracts, with the addition of those more internal, form an excellent protection to the young bud which would otherwise be exposed to danger of injury from the sand, often blown against it with great violence by the frequent high winds. Growing in company with *S. grandifolius*, and in considerable quantities, are *Apium australe*, *Samolus repens*, *Salicornia australis*, and the remarkable grass *Agropyrum coxii*.* This latter forms large sheets lying on the sand. It spreads by means of rather stout underground stems. Its extremely supple filiform leaves are so much incurved as to

* For the various new species mentioned, see further on, towards the conclusion of the article.

form an almost closed pipe, into which the dry air can with difficulty penetrate. A transverse section of the leaf shows that it is conduplicate, and appearing almost as if terete. The two halves of the leaf are slightly asymmetrical. Between the margins of the leaf is a very narrow opening, which leads into a wider channel in which the midrib projects. On each side of the midrib are one or two, perhaps more, lateral furrows reaching more than halfway to the dorsal surface of the leaf. The epidermis of the dorsal surface has a fairly thick cuticle and three layers of cells; that of the ventral surface consists of one row of rounded cells with thin walls, a few of the cells being drawn out into unicellular hairs. The stomata are situated in the furrows, and the guard-cells are sunk below the level of the epidermal cells. The other plants mentioned above, excepting *Sonchus grandifolius*, are all common New Zealand halophytes with thick leaves and much-creeping underground stems.

Besides the sand having blown on to ledges, it is often drifted against the lower parts of rocks, and forms there a plant-station which puts one in mind of some of the slopes of fine limestone *débris* in the Southern Alps of the South Island of New Zealand. In such unstable ground grows the extremely succulent *Atriplex billardieri*, while patches of *Tillæa moschata* are abundant.

Stony Sea-shore.

The only locality where I examined this formation was Te Whakaru. Unfortunately, my notes are so few that I can only give very general and by no means exact details. So far as I can remember, the shore at Te Whakaru varies from large loose slabs of stone piled one upon another to coarse gravelly sand, containing large quantities of broken shells and having very many rocks rising out of it. Such a shore is much more stable than the dry sandy one before described; the presence of stones on the surface helps to conserve the moisture, so offering permanently moist spots for the ramification of roots, and the large rocks afford shade and shelter. In consequence of these altogether more hospitable edaphic conditions, the stony shore formation is richer in species and its plant-covering more dense than the sandy shore, nor are special adaptations against shifting sand or such strongly marked xerophytic structure indispensable. All the same, the rich development of the underground stem and lowly habit of growth to be found in all the species—*Urtica australis* excepted—fits them both for resisting drought and the attacks of sheep.

Growing on the sand close to high-water mark are *Rumex neglectus*(?), with its leaves flattened close to the ground, *Ranunculus acaulis*, *Cotula muelleri*, and an introduced

species of *Trifolium*. Within a few metres of high-water mark the strand, sloping upwards, gradually merges into the gently sloping peaty ground, which in some places is carpeted with grasses, and in others has small belts of *Olearia traversii* coming right down to the shore.

Just at the junction of shore and meadow is a turf of *Selliera radicans*, a plant with a slender stem creeping on or close to the surface of the ground, and with numerous short roots descending into the gravel; its thick leaves also are pressed close against the ground. That very curious umbelliferous plant, *Crantzia lineata*, also forms a turf in similar situations. Its rush-like hollow leaves are described by Asa Gray as "petioles in place of leaves" (22, p. 205), while Hooker, in the "Flora Antarctica" (30), speaking of specimens from the Plate River, remarks that the leaves sometimes expand into a plane linear-lanceolate obtuse lamina. Goebel calls attention to the same fact (21, pp. 45, 46), and shows clearly that the peculiar structure of *Crantzia* is a protection against drought, although the South American form grows in swampy meadows. How efficient such an adaptation is for xerophytic conditions, and yet how it can live also in hygrophytic stations, is well illustrated by the Chatham Island plant, which I collected in very wet swamps, on fairly dry sand dunes, on rocks by the sea exposed to frequent drenching with salt water, on extremely dry limestone rocks, and in the shade of the forest on moist peaty ground. Near New Brighton, Canterbury, New Zealand, it grows in a *Phormium* swamp on the bank of the River Avon, subject to some hours' immersion daily in water, which is often slightly brackish, and even at times extremely salt.

Growing near the rocks which jut out of the stony shore is *Urtica australis*, a very large nettle, which, as will be seen further on, forms thickets in some parts of the island. At Te Whakaru it is not very tall, being 30 cm. to 35 cm. in height, but the leaves measured 15 cm. by 10 cm. Its thick stems, 1·5 cm. in diameter, enable it to resist the wind. Here and there on the shore grows the introduced *Plantago media*, which is so much reduced in size and changed generally that it might easily be taken for a different species, were it not for examples of the type growing in a position more favourable for its development further inland.

No doubt a number of other plants occur as constituents of this formation, but none are mentioned in my notes. But, at any rate, the formation is distinctly a modified one, for not only have exotic plants invaded it, but it must have been much changed by sheep, since Te Whakaru was one of the first European settlements on the island.

Rocky Sea-shore.

This formation, closely related to the stony shore, consists of scattered assemblages of plants living on low and often flat rocks, exposed to sea-spray and subject at times to complete drenching by the waves. The station is eminently xerophytic, but the crevices and hollows often contain a good deal of peaty soil, which easily becomes saturated with water during the frequent showers. The only rock-formation of this character studied was at Te Whakaru. In those places on the rocks where earth had filled up the chinks, crevices, or hollows, is often a fairly dense covering of *Crantzia lineata* and *Samolus repens;* in similar situations are large rounded green patches, 15 cm. in diameter, of *Triglochin striatum* and a small species of *Schœnus*, or occasionally *Tillæa moschata* forms still larger patches. This latter plant has red stems and numerous very small but exceedingly succulent leaves.

In crevices of the rocks where there is not much soil *Senecio radiolatus* and a curious species of *Senecio* with entire leaves and solitary flower-heads grows here and there. This latter may be merely a depauperated form of *Senecio lautus.* Seedlings of *Olearia traversii* are not uncommon even on such rocks as are surrounded at high water by the sea. *Pratia arenaria,* a plant occurring in almost every plant-formation on the island, not excepting *Sphagnum* bogs, and a few plants of the trailing *Chenopodium triandrum* complete the list.

Maritime Cliffs and Large Rocks.

Here are included only those lower portions of the coastal cliffs which in many cases, at some time or another, are exposed to the sea-spray, the degree of exposure varying considerably according to the proximity of the rock or cliff to the sea, while often the landward side of many large rocks may never be under the influence of the sea-spray at all. Also here are included certain cliffs situated at a little distance from the sea along lagoons, &c., such as at Lake Waikaua, which, originally actual maritime cliffs, have, since the cutting-off of such lagoons from the sea, become clothed with a modified vegetation. The highest portions of certain cliffs, especially those of the south coast, bear an altogether different vegetation, which in the latter region is in many places closely related to "tableland forest." The maritime cliffs offer two different kinds of stations: that of the more or less solid portions of the rock and that of sand lodged on flat places or ledges, already discussed.

The plants of the more or less solid rock are such as can, by means of long roots, penetrate the rock through its crevices,

thus procuring a sufficiency of water, which they store up in certain tissues, or prevent escaping too quickly by special modifications of the leaves. *Veronica chathamica* is the most characteristic plant of this formation. It roots in crevices and clefts of the rocks, which often contain a certain amount of peat, varying in depth in some particular cases from 5 cm. to 6·3 cm. From the crevice issues a rather thick main stem, from which numerous lateral very supple branches proceed, trailing over the surface of the rock in all directions, or hanging downwards over its steeper portions. The leaves in the bud have the usual decussate arrangement of the *Veronicas*, and the first two fully formed leaves are in their normal position; but all the other leaves are more or less twisted at their bases, so as to bring the upper surface to the light, the shoot, viewed from the back, showing only the under-surface of the leaves. Even where a vertical cutting is rooted in a flower-pot the newly formed shoot is plagiotropous almost from the first, being bent at right angles to the parent stem, and with all the leaves twisted at the base, so as to bring them into two opposite lateral rows. In nature the leaves are usually somewhat crowded near the ends of the branches, which are quite bare below. The leaves themselves are rather thick and fleshy, pale-green in colour, and covered with numerous short downy hairs on both surfaces and on the margin. They vary considerably in size, and plants differing markedly in this particular may be observed growing side by side. This variation seems the more remarkable, since the life-conditions to which *V. chathamica* is exposed might well be expected to have produced an invariable species.

Geranium traversii, described at some length in the next section, is also common on maritime cliffs in all parts of the coast. In many places the vegetation becomes somewhat luxuriant through great sheets of *Mesembryanthemum australe*, accompanied by smaller sheets of *Salicornia australis* and large green patches of *Apium australe* hanging down and covering the rock. Associated with the above are dotted about plants of *Chenopodium glaucum* and *Atriplex patula*. Occasionally, even in places where the sea-spray reaches at times, are stunted, gnarled specimens of *Olearia traversii*.

The fern *Lomaria dura* probably grows on the maritime rocks proper, as it does, *e.g.*, at the Bluff, in New Zealand; but in Chatham Island it is especially luxuriant on the cliffs bordering the Waikaua Lagoon. Its dimensions vary according to the amount of soil and the moisture of its station. In stations facing south on the very steep cliffs it forms colonies to the exclusion of all other vegetation. The leaves of one plant measured 64 cm. in length by 12 cm. in breadth, and it had a stem like a small tree fern, 21 cm. long. Near this

mass of *L. dura* grows the large nettle, while below *Apium australe* is abundant. On the dry solid rock where soil is altogether absent *L. dura* is of very much smaller dimensions, but I took no measurements.

Shallow Peaty Soil underlaid by Rock.

As the rock weathers away and becomes flatter the vegetation described above becomes more and more abundant until finally a considerable layer of peat results, which supports a plant population different in many respects from that of the original rock. Te Whakaru Island offers an example of such a station, and exhibits the gradual change from the lowly vegetation of the flat ground close to the sea to the grove of *O. traversii* on the higher ground, many of which trees are of the largest size to which that species can attain. The open parts of the island are covered with a dense carpet of *Mesembryanthemum australe*, some of which have red and some green leaves. Here and there where the latter has not taken possession, especially in the rather moist places, are patches of turf consisting of *Crantzia lineata, Triglochin striatum, Cotula muelleri, Pratia arenaria, Selliera radicans, Schœnus* sp., and *Ranunculus acaulis*. Sometimes the *Pratia* forms large patches unmixed with any other vegetation. Where the surface of the ground is higher and the soil probably deeper grows the endemic *Cotula featherstonii* (Plate XIV.). This plant forms large colonies on the dry peaty ground in which the mutton-birds make their holes, probably the presence of the birds' manure defining the habitat of the plant. It possesses a stout, smooth, upright stem, 13 mm. or more in diameter, which gives off about five branches rather close together, which latter again branch in a similar manner, the whole plant being from 15 cm. to 30 cm. in height. The leaves are soft and slightly succulent, but not sufficiently so for water to be squeezed out of them. They are crowded into rosettes at the extremities of the branches, the internodes being very short. The whole plant is of a greyish colour, and puts one in mind of the biennial stock (*Matthiola incana*). The roots are stout, strong, and woody, and form, with their rootlets, a mat, which lays hold firmly of the adjacent soil. As to the duration of life of *C. featherstonii*, there seems little doubt but that the plant is a perennial. At Maturakau *Myosotidium nobile* grows in large clumps near those of *C. featherstonii* (Plate XV.), all the rest of the ground being covered by *Mesembryanthemum australe*, which also hangs in sheets from the adjacent cliffs. On Te Whakaru Island a few plants of *Phormium tenax* on the peat and others on the rocks testify to the former greater abundance of this plant;

indeed, the whole formation, especially as seen at Te Whakaru, must have been enormously modified.

Limestone Cliffs and Rocks.

These cliffs bound the shore of the great lagoon in various places, while often rocks extend from their base into the water. At one time the base of the cliffs was laved by the waters of the ocean, so that they are closely related to maritime cliffs. From such cliffs, as before described, they differ in their inland position and consequent freedom from the influence of salt water, also in the very different nature of the rock. Many of their plant inhabitants are doubtless part of the original flora, while others have come from the neighbouring inland formations, their seeds blown into crevices of the rocks or brought by birds, while the xerophytic structure of the plants has enabled them to hold their own in such a position.

Taking the case of New Zealand, it seems well established that sea-coast plants can continue to occupy an inland ancient maritime station. Mr. T. Kirk has called attention to such an instance (42^2), and I have also shown that *Angelica geniculata* occurs at the lower Waimakariri Gorge, on the upper Canterbury Plains (10^2, p. 101), a station which Captain Hutton brings good evidence to show was formerly maritime (33^2).

As in all rock-formations, there is here no struggle for existence amongst the plants. Any plant which can gain a foothold will be unmolested by its neighbours. Many parts of the cliffs are quite bare; others are clothed with a fairly abundant vegetation. Very characteristic of this formation is *Veronica dieffenbachii*, the branches of which spread out laterally or hang downwards from a thick main stem firmly embedded in some crevice. Its leaves are confined to the extremities of the branches. They are rather thick and fleshy, 6·5 cm. long by 1·9 cm. broad. The shoots, unlike those of *V. chathamica*, are not at all dorsi-ventral, and the branches are so extremely pliant that a twig 4 mm. in diameter can be rolled round and round the finger without breaking. Other plants growing in company with *V. dieffenbachii* are—*Linum monogynum* var. *chathamicum*, its white flowers striped or flaked with pale-blue; *Senecio lautus; Phormium tenax; Leucopogon richei; Acæna novæ-zelandiæ*. In hollows in the cliff *Adiantum affine* is very abundant, while in some places its delicate fronds form great sheets of greenery on the rocks. *Geranium traversii*, another common plant of this formation, can thrive in extremely dry positions; for example, I noted it growing on a perfectly dry limestone rock near the margin of the lagoon. Its roots are very thick and stout; one example measured was 1·5 cm. in diameter, and at 10 cm. from the

base of the root 7·5 mm. This particular root was 70 cm. long, and three other roots of nearly equal length and thickness were given off from the root axis. The main stem is usually very short and stout; in one case measured it was 1 cm. long and 9 mm. in diameter. From this stem arise radical leaves and trailing stems. The radical leaves are furnished with very thick petioles, 6·5 mm. in length and 4 mm. in diameter. The petioles are pale-pink in colour, especially below, and densely pubescent with short white hairs; at the base they are sheathing, and furnished with triangular stipules. The leaf-blade is reniform-orbicular and deeply lobed, rather thick, and on each surface is covered with pubescence, which gives it a somewhat silvery appearance. Cultivated specimens, which have originated from self-sown seed in my garden, have the leaves much less succulent than the wild plant, the petioles very much longer, more slender, and without a trace of the red colouring.

Limestone Forest.

The limestone cliffs do not form an unbroken precipitous wall all round the lagoon, but they are separated by steep banks and hollows, arising probably from weathering of the original rock. In such places certain trees grow in association, so as to form small woods. The undergrowth of these woods is almost entirely destroyed by the ravages of stock, and possibly the proportion of the species of trees is no longer what it originally was. But what gives special interest to the formation is the presence of *Sophora chathamica.* Regarding this tree Mr. H. H. Travers wrote (51, p. 178): "In connection with the recent introduction of the New Zealand pigeon,* I may mention that in a small tract of bush on the margin of the great lagoon I found three trees of the *Edwardsia microphylla,* all growing close together, and being the only specimens of that plant which I saw on either island. They were not in flower or fruit at the time. They were apparently all of equal age, and were about 5 in. in diameter and 15 ft. in height. Mr. Hunt, to whom I pointed them out, stated that he had never seen the plant before. During my residence at Pitt Island I was in the habit of examining the coast of the bay in which Mr. Hunt's house is situated twice a day for some months, and on one occasion I saw a sawn plank of totara, and on another a seed of the *Edwardsia,* which had evidently been washed from New Zealand. The

* I may point out that the pigeon is a distinct species from that of New Zealand (see remarks on this species, *Carpophaga chathamiensis,* Rothschild, by Sir W. Buller, in Trans. N.Z. Inst., 1892, vol. xxiv., p. 80).

seed was hard and apparently sound. I gave it to Mr. Hunt, who sowed it, but I have not yet heard the result." This statement of Travers's has seemed so reasonable that Mr. Hemsley writes of "the doubtful occurrence" of *Sophora* in the Chatham Islands (28). That *S. chathamica* is indigenous in Chatham Island there can, however, be no doubt. Even if, unaided by man in any way, it had arrived a few years before Mr. Travers's visit it would have been indigenous, of course; but it has probably occupied Chatham Island since that land was first colonised by its arborescent plant inhabitants. It occurs abundantly in all the small woods along the lagoon, and in quite as great a proportion as the other trees. Moreover, its seedling form is different from that of any other species or variety of the genus, as I pointed out some years ago (9, p. 337); and so far as I have been able to ascertain, both from Mr. Cox and from personal observation, it does not at any period of its existence assume a xerophytic habit of growth (10, p. 279). Concerning this latter matter, as mentioned towards the end of this paper, I hope before long to make a definite statement. The other forest trees found in conjunction with *S. chathamica* are *Plagianthus chathamicus*, *Pseudopanax chathamicus*, *Coprosma chathamica*, *Olearia traversii*, *Myrsine chathamica*, and *Corokia macrocarpa*, of which the *Sophora*, the *Plagianthus*, and the *Pseudopanax* are the most abundant.

Why *S. chathamica* should be confined to the limestone and found in no other part of Chatham Island, when a closely allied species grows abundantly over volcanic rock in New Zealand, is a very difficult question to answer. It may simply be that it cannot compete in a wet position with the other forest trees, and that the limestone forest is drier than any of the other forest-formations on the island. At any rate, it is a very striking example of the local distribution of a plant, and of how a fall of a few metres in the general level of Chatham Island would probably exterminate the species. The seeds of *Sophora* found on the beaches by Travers and others were most likely merely from the trees by the lagoon, and had never come from New Zealand at all.

Lagoon.

If a portion of the sea be cut off from the main body of water by an enclosing barrier of sand a lagoon is the result, of which Te Whanga is the most important example. Its waters are usually shallow for a considerable depth from the shore, and so are favourable for plant-life; but, being brackish, only a limited number of phanerogams can exist in this station, while frequent winds agitate the surface of the water to such a degree that only those plants specially adapted to

resist the action of waves can exist. In consequence the lagoons of Chatham Island possess only a very small phanerogamic flora; nor so far as observed were *Algæ* numerous. *Ruppia maritima* often occupies large portions of such shallow places in lagoons, and its leaves and stems, floating at times on the surface of the water, form a mat of such density as to have attracted the attention of the Maoris, who call it the "eels' blanket." The floor of the lagoons consists of sand or of sandy peaty mud, formed from the decay of many generations of plants. Such muddy peat is the commencement of a transition from the bed of a lagoon to salt meadow, for as it gradually accumulates it rises out of the water and becomes at once occupied by an abundant plant population. Such a spot forms the line of tension between lagoon and salt meadow. In several places Te Whanga Lagoon is, as before pointed out, sufficiently shallow to be crossed on horseback, the depth of water at the crossing varying according to the direction of the wind; and with a north-west wind blowing in summer it may be quite dry, and clouds of dust and sand mark its position. On this portion of the lagoon-bed large round patches of *Samolus repens* are abundant; so here is one of the most characteristic of salt-meadow plants taking possession of the ground almost before the station is fit to receive it. A very slight rise indeed of the land and the bed of the lagoon would be transformed by nature into salt meadow, which probably might be succeeded by forest, especially if the land were elevated a little more. It is also easily conceivable how such a lagoon could be transformed into a bog, and it seems very probable indeed that the low-lying boggy ground in the north-west of the island has had this origin, as suggested by Haast (23).

Lagoon-shore.

The vegetation of the lagoon-shore, as shown above, is not directly related to that of the sea-shore proper, but is rather an embryonic salt meadow. Of course, originally, before the lagoon was cut off from the ocean, it must have been true sea-shore, though possibly its plants might even then have been affected by the lime in the soil.

I had only an opportunity of examining a portion of the western shore in one or two places, and have no notes at all regarding the eastern shore. The soil consists of sandy peat usually very wet, but varying considerably in its water-content. That portion within reach of the wash of the waves is sopping wet, and so soft that one cannot tread on it without sinking halfway to one's knees. There *Crantzia lineata* grows most luxuriantly, forming large green masses. *Callitriche muelleri*, *Limosella aquatica*, var. *tenuifolia*, *Cotula*

muelleri, Cotula coronopifolia, and *Eleocharis gracillima* are also abundant, and form a kind of turf on the peaty mud. Drier parts of the shore are occupied by thickets of *Urtica australis*, while in other places are very large patches of *Samolus repens*. Where the shore is drier still, and altogether out of reach of the water at any time, is a grassy flat made up of certain grasses, of which I have no specimens—*Cotula muelleri, Samolus repens, Selliera radicans, Crantzia lineata, Pratia arenaria*, and probably a number of other plants not specially noted.

Salt Meadow.

Along the great lagoon, especially on its eastern side, are large stretches of flat land bordered on the east by forest, at one time probably the bed of the lagoon, but now, so far as I can remember, salt meadow. Unfortunately, I had no opportunity of examining this interesting formation, and so must leave it undescribed for the present.

Running Water.

Chatham Island, with its many lagoons, lakes, and streams, might reasonably be expected to contain a considerable number of phanerogamic water plants. On the contrary, as pointed out by Travers (51, p. 177), these are by no means plentiful. Most of the streams are very sluggish, their slowly moving water is of a dark-brown colour, and their bed a deep layer of peaty mud. During the rains of winter they often overflow, and so give rise to numerous swamps of greater or less extent, which, if in a forest, contain the characteristic swampy forest trees. Such streams sometimes contain no vegetation beyond certain *Algæ;* in others *Myriophyllum elatinoides* and *Polygonum minus*, var. *decipiens*, grow in company with one another; while in the very still pools of forest streams *Callitriche muelleri* is sometimes abundant, growing at 0·5 m. or more below the surface of the water and extending on to the damp floor of the forest. *Potamogeton natans* is by no means common, though it is occasionally met with in shallow streams and in pools formed from their overflow. The introduced watercress (*Nasturtium officinale*) is abundant in many of the small streams, but it does not seem to attain to anything like the same dimensions as in certain South Island waters. On the margin of the streams, growing right in the water, are usually a number of swamp plants—*Carices, Coprosma propinqua, Arundo conspicua*, &c.—or, if the stream be within a belt of trees on the tableland, *Myrsine coxii* is often abundant, growing right in the water. A station of this kind offers much the same conditions as a swamp, but is more favourable for plant-life, the constantly moving water preventing

stagnation. Rapidly flowing streams are very rare, and, unfortunately, I have no notes regarding their plant-life.

Swamps.

The swamp formation occurs principally in the lowest portions of the central and northern part of Chatham Island, in the immediate vicinity of lakes, lagoons, or sluggish streams, and is distinctly a transition, in some cases, between lake and forest; indeed, the line of tension may be often observed where swamp and forest plants intermingle. The swamp at the southern end of Lake Huro is easy to examine, and is of especial interest, since it offers every transition from the waters of the lake to the ordinary lowland forest. The vegetation of the swamp seems determined by the average depth of the water which more or less covers its floor. Where the water is deepest there is to all intents and purposes an original formation, for the ground is altogether too boggy to permit the inroads of cattle; but in all other parts the trampling of cattle and horses has consolidated the ground more or less and reduced its water-content, thus making it suitable for other plants, both indigenous and introduced. The floor of the swamp in its unchanged portions consists of black peaty mud, upon which it would probably not be safe to walk. Everywhere are large pools of water, 50 cm., more or less, in depth; while in winter the whole floor of the swamp, I learn from Mr. Cox, is under water. Here there are no shrubs of any kind. The vegetation consists of the curious restiaceous plant *Leptocarpus simplex*, a well-marked xerophyte, which in New Zealand occurs in salt meadows and sand-dunes (12^2, p. 119). In this formation *Leptocarpus* often forms very large patches, to the complete exclusion of every other plant. Growing near but not mixed with the *Leptocarpus* is *Carex secta** in great quantities, its "trunk" composed in large part of dead rhizomes and roots matted together, on the summit of which the living plant, raised out of the water, can avoid excess of moisture, sending its roots far down into the decayed and semi-decayed "trunk."

As the water of the swamp decreases in quantity the ground becomes quite covered with vegetation and decaying vegetable matter. There the floor is very uneven, with its many mounds of peat and decaying vegetation separated from one another by holes full of water. In such a part of the swamp *Coprosma propinqua* is very abundant, making a sub-

* Pastor G. Kükenthal, who is preparing an account of the genera *Carex* and *Uncinia* for "Das Pflanzenreich," informs me that he considers *C. secta* distinct from the European *C. paniculata*, to which Cheeseman had previously referred it as a variety (8).

formation which occurs so frequently on the island as to have attracted the notice of the settlers, who call it "Mingimingi scrub." Mixed with the *Coprosma* are the tall grass *Arundo conspicua*, *Phormium tenax*, *Carex secta*, *Carex forsteri*(?), *Deschampsia cæspitosa*, and quantities of *Epilobium pallidiflorum*, *E. billardierianum*, *E. chionanthum* var.; and a large species of *Astelia* which is perhaps new.

As soon as the swamp becomes a shade drier small trees make their appearance, and this point is evidently the line of tension between swamp and forest. The first tree to appear is the xerophytic *Olearia traversii*; then *Dracophyllum arboreum* becomes abundant, mixed with *Coriaria ruscifolia*, *Pseudopanax chathamica*, and *Myrsine coxii*. *Hymenanthera chathamica* and *Senecio huntii* also occur to some extent. Mixed with this arborescent vegetation are all the swamp plants mentioned before, *Leptocarpus simplex* excepted, and large quantities of the fern *Lomaria procera*. Such a "scrub" is often extremely dense, and almost impossible to be traversed. On the banks of Sandstone Creek a very dense formation of this kind, almost in its virgin state, may be seen.

As the water-content of the swamp gradually decreases, through accumulations of vegetable matter becoming peat, so do the trees become more and more numerous, until finally, as in the case of Lake Huro, mentioned above, a true forest makes its appearance. The trees of the formation need not be reduced to mere shrubs; on the contrary, the *Pseudopanax*, *Coriaria*, and others, attain in the Huro Swamp a height of 6 m. Wherever a sluggish stream flows through a lowland forest, and at times inundates the neighbouring ground, the character of the forest changes, and a formation of *Corynocarpus lævigata*, *Coprosma chathamica*, *Rhopalostylis baueri*(?), *Hymenanthera chathamica*, and *Myrsine chathamica* changes to one of *Myrsine coxii*, *Dracophyllum arboreum*, and *Olearia traversii*, this latter plant being of more lowly growth than when growing in the drier forest.

Those of the swamp plants which differ little from the New Zealand forms of the same species growing under similar conditions need not be further dealt with here; *Dracophyllum arboreum* and *Senecio huntii* are treated of at some length further on, when dealing with the "tableland forest," so there only remains *Myrsine coxii* for special mention. This is a rather twiggy shrub, attaining under favourable circumstances a height of 3 m. or 4 m. Its leaves are close together, and form rather a dense mass at the ends of the branches. They are small, averaging about 1·8 cm., including the leaf-stalk, by 8 mm., and are narrow-obovate in shape. The fruit is of a beautiful mauve colour, and was doubtless originally distributed by means of native birds. These latter,

however, are for the most part nearly extinct, so this method of distribution no longer exists. However, as Mr. G. M. Thomson points out for New Zealand, introduced birds (50, p. 317) are now playing a most important *rôle* in the spread of plants; indeed, they may very well supply the place of the indigenous birds in this particular. *Myrsine coxii* is the first of all the Chatham Island trees to come into bloom, flowering as it does from the end of July.

Most of the swamp formation of Chatham Island has been much modified through consolidation of the soil consequent on the trampling of cattle and horses, which also destroy the trees which otherwise would seize on the "reclaimed" ground; so instead of following its natural course and becoming a forest the swamp becomes gradually transformed into meadow land, in which certain native and introduced plants which are not destroyed by the grazing of animals become dominant and form a turf.

Lowland Forest.

The climate of Chatham Island is distinctly a "forest climate" (48, p. 178)—that is, the whole island would be covered with forest were the edaphic conditions suitable. These conditions vary much for different kinds of trees, but, generally speaking, the soil must be deep enough for the trees to become firmly fixed; it must be firm, but loose enough to contain a sufficiency of oxygen; it must be well watered, but not saturated with water; and there must be enough drainage to forbid stagnation. In addition, humus is usually present in large quantities, while nitrifying bacteria and various fungi abound. Finally, there must not be too great a quantity of inorganic salts or of humic acids in the soil (53, p. 292). From the above it is easy to see the reason why, notwithstanding its forest climate, so much of Chatham Island is without trees, since so large an area is occupied by swamps, bogs, and wet ground. It is not quite so easy to understand how a large area quite suitable for tree-life is also treeless, being occupied chiefly by the fern *Pteris esculenta.* In the section of this paper dealing with burning of the vegetation an explanation of this anomaly is suggested.

The lowland forest of Chatham Island, though consisting of trees very much smaller in their dimensions than those which make up the forests of New Zealand, are distinctly forests nevertheless, and not mere assemblages of large shrubs. Below, all the trees have bare trunks, sometimes of considerable thickness, and above, spreading branches covered with abundant foliage. Seen from a distance the forest is blackish-green in colour, but not nearly of so dark a hue as is the subalpine *Fagus* forest of New Zealand. If a forest be viewed

from an eminence, so that the tree-tops can be looked down upon, it will be noticed that these form a compact and level mass of greenery, no one tree rising above its fellows. Within the forest the customary shrubby growths of the New Zealand mixed forest are absent; here, indeed, are no shrubs of any kind, if *Piper excelsum* be excepted, their place being taken up entirely by tree ferns, many of which are of very great dimensions. The ground itself may be bare, or covered with ferns or various lowly plants. On the stems of the tree ferns grow many epiphytes, seedling plants, and even young trees of no small size. Two lianes, *Rhipogonum scandens* and *Muhlenbeckia adpressa*, climb to the tree-tops and mingle their foliage with that of the trees, while the bamboo-like stems of the former and the rope-like stems of the latter form at times a complete entanglement which it is very difficult to penetrate.

The soil of the forest consists sometimes of "red clay," sometimes of peaty loam, or, in the case of the coastal forest, of sand underlaid by peaty loam, while a considerable surface layer of humus, resulting from the decaying vegetation, is always present. The trees, with one exception, are evergreen, their leaves numerous, of fair size, and in some cases rather thick. Here and there the palm, *Rhopalostylis baueri*(?), raises up its huge and graceful leaves to the light through the leafy canopy. The dense foliage of the tree-tops tends to keep the interior of the forest moist and its atmosphere damp. This is plainly manifest by the filmy ferns, liverworts, and mosses, formerly common in many places, but now somewhat rare in lowland forests; indeed, their presence or absence may be taken as a measure of the average humidity of the atmosphere.

As is well known, the New Zealand lowland forest consists usually of a very great number of trees and shrubs, but that of the Chatham Islands, on the contrary, consists of quite a few species, and these occur in remarkably equal quantities. To enumerate them in what is perhaps their order of most frequent occurrence these are: (1) *Corynocarpus lævigata*, (2) *Olearia traversii*, (3) *Coprosma chathamica*, (4) *Hymenanthera chathamica*, (5) *Myrsine chathamica*, (6) *Corokia macrocarpa*, (7) *Pseudopanax chathamica*, (8) *Veronica gigantea*, (9) *Piper excelsum*, (10) *Rhopalostylis baueri*(?). Besides the above, *Plagianthus chathamicus* is abundant in some localities. This is a very different combination indeed from that of any New Zealand forest. Of the eleven trees six are endemic, the palm is perhaps the same as that of the Kermadecs, *Hymenanthera chathamica* is recorded from only one locality in New Zealand, and *Myrsine chathamica* from one station in Stewart Island. All the trees vary in size according to the character of the soil and extent of the forest. In

the "bush" between Te Whanga and Petre Bay there are trees 15 m. in height or more, but usually they are smaller, and vary from 6 m. to 13 m. On the outskirts of the forest, and occasionally within its interior, especially in very wet ground, *Senecio huntii* and *Dracophyllum arboreum* occur in greater or less abundance. These do not properly belong to this formation at all, and such portions may perhaps be looked upon as remnants of a former tableland forest.

Although the conditions under which the lowland forest plant-formation exists are distinctly hygrophytic, and the formation a hygrophytic one, belonging to Schimper's great class of "rain forests," yet that part of the formation which is exposed to almost constant and often very severe winds—viz., the tree-tops—shows in its general form and in the structure of the leaves of most of its members certain xerophytic adaptations. Thus the general closeness of the tree-tops, the density of the foliage, the remarkable uniformity of height of the trees, and the lowness of their growth are in direct relation to the strong sea-breezes which by turns strike the forest from every side. Such direct action of the wind is very markedly shown in those isolated groves of *Corynocarpus lævigata* which have been left in certain places when the remainder of the forest has been destroyed by human agency, their branches and leaves on the windward side forming a dense flattened mass, in striking contrast to the more open growth on the sheltered side.

Regarding the leaves themselves of the forest trees, those of *Corynocarpus lævigata* are in appearance not unlike those of the North American *Magnolia grandiflora*. They are rather thick and leathery, bright-green in colour, oblong-lanceolate or sometimes obovate in shape. Their size varies; certain leaves measured varied in size of blade from 12 cm. by 6 cm. to 9 cm. by 5·4 cm. The epidermis is three-layered. *Pseudopanax chathamica* has thick leaves, dark dull-green in colour on the upper surface, but much paler beneath. The leaf-blade measures 15 cm. or 16 cm. by 3·6 cm., and points upwards at an angle of about 45° to the axis of the shoot. The petiole is short and very stout. There is a four- or sometimes three-layered epidermis on the upper surface; the outer wall of the first layer is strongly cuticularized. *Myrsine chathamica* has leaves rather thick and leathery, obovate or obovate-oblong, their lamina 5·5 cm. by 3 cm., rather dull-green in colour, and crowded at the ends of the branches. *Corokia macrocarpa* has leaves lanceolate or oblong-lanceolate in shape, with the lamina 7·2 cm. by 3 cm., or rather shorter, and the upper surface of a shining dark-green colour. The under-surface is white, with very dense tomentum. The margin of the leaf or the

sides of the lamina are often much recurved or rolled back, rendering the under-surface of the leaf concave. The epidermis has a much-thickened outer wall, and the cells are equal in length to those of the palisade parenchyma, while their long axis is at right angles to the surface of the leaf. *Hymenanthera chathamica** has lanceolate leaves, which are thick and coriaceous, and the lamina is 8 cm. by 2·7 cm., more or less. They are of a rather pale-green colour. The epidermis of the upper surface is three-layered, the lateral walls of the two inner layers being very thin. A stereome sheath surrounds the vascular bundles, and adjacent to some of them is a colourless water-tissue. *Coprosma chathamica* has leaves rather thinner in texture than most of the other forest trees, oblong or obovate in shape and variable in size, the lamina often being about 4·9 cm. by 2·3 cm. They are dark-green and shining on the upper surface, and very pale on the under-surface. The small pits ("*Domatia*") common on the under-surface of the leaf of *Coprosmas*, and first called attention to by Cheeseman (7), at the junction of a vein with the midrib, are very distinct. Mr. Hamilton has written about them more recently (32), but has added nothing to our knowledge of their function. The epidermis is two-layered, and a transverse section of the leaf shows a layer of water-tissue stretching from the epidermal cells to the vascular bundles through the palisade parenchyma. *Veronica gigantea* has narrow-lanceolate, quite sessile leaves, averaging probably about 8·3 cm. by 1·8 cm. They are soft, bright-green in colour on the upper surface, thicker in texture than any form of *V. salicifolia* with which I am acquainted, and crowded together rather closely at the ends of the branches. *Piper excelsum* is distinctly a hygrophyte. It has very thin dark-green leaves, with their laminæ 10·6 cm. long by 9·3 cm. broad, and the apex drawn out to a fine point.

With the exception of *O. traversii* and *Corokia macrocarpa*, the former having multitudes of white daisy-like flower-heads, and the latter many small but bright-yellow flowers, the trees of the lowland forest have very inconspicuous blooms. Their fruits, on the contrary, are often large and showy. For example, *Corynocarpus lævigata* has great clusters of very large fruits, each measuring 4 cm. by 2 cm.; *Myrsine chathamica* has the naked branches below the leaves covered with most beautiful mauve-coloured drupes, which, according to Mr. Cox, take fully a year to develope their brilliant colour. The bare stems of *Hymenanthera chathamica* are similarly covered with large white berries. *Corokia macrocarpa* is frequently

* Diels's figure of the anatomy of the leaf of *H. latifolia* (16, p. 230) shows almost identical structure with that of the Chatham Island plant.

covered thickly with its bright-orange drupes, and *Coprosma chathamica* has large drupes, 12 cm. by 9 cm., which are probably of a yellow colour.

The tree ferns composing a large part of the forest undergrowth are chiefly *Dicksonia squarrosa* and *D. antarctica.* Besides these *Cyathea dealbata* and *Cyathea medullaris* occur, but more sparingly. Sometimes the tree ferns grow very closely, and do not permit many other plants to spring up amongst them; at other times they are further apart, and the ground is then densely covered with ferns similar to those of the New Zealand forest growing under the same circumstances, such as *Asplenium bulbiferum*, *A. falcatum*, *Lomaria lanceolata*, *Aspidium aculeatum*, *Hymenophyllum demissum*, and others.

Besides the ferns, *Epilobium rotundifolium*, *E. linnæoides*, *Uncinia australis*(?), a few grasses, a species of *Hydrocotyle* with very large leaves, which is either *H. robusta* or an undescribed endemic species, and often great numbers of seedling trees, form the general carpet of the forest. In places where the humus is deep are the orchids *Pterostylis banksii* and *Acianthus sinclairii.* On the floor of very damp forests, in places where stock have access, and where much of the original vegetation is destroyed, *Callitriche muelleri* and *Crantzia lineata* carpet the ground, mixed with considerable quantities of *Ranunculus rivularis*, the *Crantzia* being of very great size. At the present time the forest carpet is in many places almost obliterated by the trampling and grazing of stock; indeed, in no place now on the island is the lowland forest in its virgin condition.

The stems of the tree ferns hold in their matted roots and the bases of their stipes a good deal of water, and also no inconsiderable amount of fine humus, which must have originated from the decay of the leaves. Thus it is that many plants, crowded out probably from the soil by more vigorous competitors, have chosen the stems of the tree ferns for their permanent home; others live equally well either upon the ground or on the fern-stems. The tree-fern stems, with their good drainage conditions and the abundant food-supply from the humus, offer a most excellent station for the germination of all kinds of seeds; indeed, seedlings of the orest trees abound in such a situation. This is still more marked in the "tableland forest," under which head the matter is further discussed. Amongst the plants growing on the tree-fern stems are *Tmesipteris tannensis*, *Trichomanes venosum*, *Polypodium billardieri*, *P. pustulatum*, *Aspidium capense*, and *Earina mucronata.* Several of these plants also grow on the trunks of the forest trees, in which position the xerophyte *Polypodium serpens* is very common. Although

this latter plant grows at times on all the forest trees, it is by far most frequently met with on the smooth bark of *Corynocarpus lævigata*. Even where *Corynocarpus* is without the forest it often affords a home for this fern, which in such stations of extreme dryness grows most luxuriantly.

The lowland forest occurs in all parts of the island except on the tableland. In the neighbourhood of the Horns and at Te Awatapu the forest is intermediate in type between that of the lowland and tableland, the result perhaps of intermediate edaphic conditions. The most extensive lowland forest now existing is that between Petre Bay and Te Whanga. The volcanic hills, Korako, Wharekauri, and Maunganui, are forest-clad. In the neighbourhood of Whangamarino there is a forest of considerable size bordering on Lake Huro and covering the adjacent slopes; and finally lowland forest fringes much of the coast-line, as was shown when dealing with the sand-dunes. It has been explained how a forest may originate in a swamp; but, besides this, the beginnings of forest may be seen in those patches of "bush" which line the bottoms and sides of gullies, such gullies having been hollowed out by the action of streams. In such sheltered positions, where the drainage conditions are good, trees can easily take possession of the ground, and from thence may spread out on to the neighbouring slopes or flat land.

Heath.

One of the most important factors which determines the presence or otherwise of forests is wind. Where constant high winds are the rule, even though every other condition is eminently favourable, very few trees can gain a footing on the ground, while if such have in addition to contend against other plants better equipped for the contest, especially such as are provided with strong subterranean members, they must succumb. This accounts, I believe, for the absence of forest over much dry ground quite suitable for its reception and maintenance. For the plant-formation of such ground I propose the term "heath" rather than "meadow," since the latter name suggests the presence of grasses as the dominant plants, whereas here these latter are in the minority, and bracken fern is the most important constituent. The whole of this formation, no matter where it occurs on the island, is a modified one, so no exact presentation of its original aspect is possible. It seems to follow directly after the bog formations, and it may, I think, replace them without any intermediate stage of *Olearia-Dracophyllum* bog or *Dracophyllum* scrub having occurred.*

* For meaning of these terms, see "Bog Formations," further on.

The presence of the heath plant-formation seems to depend upon the amount of water in the soil, and, as mentioned above, upon the exposure of the station to wind, while, according to the relative dryness of the substratum, certain plants may be present or absent. Thus, the following occur only on the driest ridges: *Leucopogon richei, Cyathodes robusta, Pimelea arenaria, Isolepis nodosa, Libertia ixioides*, var. In such a position, *L. ixioides* at times almost constitutes a subformation, forming, thanks to its power of spreading by underground stems, very large patches. Its xerophytic, coriaceous, vertical, iris-like leaves also help to maintain the plant in its dry station. Growing in these *Libertia* patches, but in very limited quantities, are *Agrostis æmula, Gnaphalium involucratum, Acæna novæ-zelandiæ*, and a few stunted plants of *Dracophyllum paludosum* and *Pteris esculenta*. In many places the heath consists of nothing but *Pteris esculenta*, which often grows with great luxuriance, and attains a height of 1·5 m. or more. Where the fern is not so tall a number of other plants are found in association with it. In such positions the following were noted: *Epilobium* sp. (perhaps related to *E. novæ-zelandiæ*), *Lagenophora forsteri, Gnaphalium filicaule, Oreomyrrhis colensoi, Gentiana pleurogynoides* var. *umbellata, Pratia arenaria, Isolepis nodosa, Acæna novæ-zelandiæ, Hydrocotyle moschata, Danthonia semi-annularis, Dichelachne crinita, Thelymitra longifolia, Microtis porrifolia, Luzula* sp. Also plants of *Dracophyllum paludosum* and *Olearia semidentata* are occasionally present, a remnant of the original bog formation.

The soil of this formation is usually peaty loam, varying much in the amount of water it contains, but except on the ridges mentioned before it is never really dry. Formerly there was probably, as pointed out further on, only a limited extent of heath, with bracken as the dominant plant, and undoubtedly *Phormium tenax* would play a very important part in the vegetation. A proof of this is afforded by *Phormium* occurring in very large quantities in the hollow before mentioned, where the peat had been burned, and the steep sides of which prevent the entrance of grazing animals.

Except on the southern tableland the heath formation is found in all parts of the island; indeed, so far as I can judge, it occupies a larger area than any other formation. On the large extent of flat land raised a little above sea-level, marked "Kekerione" on the map (49), and intersected here and there by puny watercourses, wherever the surface sinks a little below the general level is boggy ground; but all the remainder, by far the greater part, is covered with bracken, varying from a vegetation of almost pure *Pteris*

esculenta to one in which that fern and *Gleichenia circinata* occur in almost equal quantities.

Lakes.

It may be remembered that I included the lowland lakes with the lagoons; the lakes here to be considered are those of the tableland. It seems very probable that such sheets of water were more numerous earlier in the history of Chatham Island, and that now they are transformed into bogs; but I can bring forward no direct evidence on this point. At the present time, in one instance—that of Lake Te Kua Taupo—the water is on one side actually gaining on the land through the beating of its waves against the soft peaty ground, which falls in large masses into the lake, bearing with it its vegetation. Where this steep bank of the lake possesses an unbroken surface grow in considerable quantities a species of *Veronica* of a spreading habit and *Aciphylla traversii*, both of which plants are in such a position safe from the attacks of sheep. The water of these lakes is, like all the other water of the island, dark-brown in colour. I noted no aquatic plants of any kind. In the shallow water near the margin of Lake Rangatapu, the largest of the tableland lakes, grow *Carex* sp. and stunted *Phormium tenax*. Here lake and bog join—the one gradually merging into the other.

Aciphylla traversii was evidently originally a bog plant, as evidenced by its reproduction in certain bogs after fire, but to which formation it belonged I cannot say. Its leaves are certainly altogether more flaccid than the New Zealand *A. colensoi*, but they are more rigid than I had been led to expect. The apex of the leaves is pointed, but it is quite soft, and will not prick the skin even when forcibly pressed against it. The plants vary considerably in size, and the female plant is taller than the male. The largest plants seen measured 80 cm. tall for the female and 33 cm. for the male. The leaves of the female were 34 cm. long, with pinnæ 17 cm. long. A transverse section of the leaf shows an extreme xerophytic structure. The guard-cells of the stomata are sunken, the cuticle is extremely thick; wedge-shaped masses of stereome abut on the resin passages, and these on the vascular bundles, alternating with and separating the palisade parenchyma, while the interior of the leaf consists of rather loose spongy parenchyma, which is completely surrounded by the stereome and palisade parenchyma. This xerophytic structure of *Aciphylla* in the Chathams was considered by Diels as quite out of keeping with the present climatic conditions (16, p. 288), and that is quite true; but, as I show, the edaphic conditions are eminently xerophytic, and can well account for its structure.

Bog Formations in General.

A very large proportion of the tableland and a considerable part of the lowland, especially on the north-west peninsula, consists of boggy ground. The vegetation of the bogs has been burnt in some places again and again, in others only occasionally, but in very few places indeed is it still in its primeval condition. To tell whether a portion of vegetation is primitive or modified is not easy. Much of the plant-covering, looking to all intents and purposes unmodified, Mr. W. Jacobs assures me has been burnt at any rate once, although that may have happened twenty years ago or more. *Phormium tenax*, which certainly played a very conspicuous part originally in the plant-covering of all places except the very wettest, is now almost extinct, and the exclusion of so large and characteristic a plant from a formation must have led to far greater extension of others with which it formerly shared the ground. The bog soil consists of peat, varying considerably in its water-content, thus leading to several distinct combinations of plants, one combination giving place to another according as the ground becomes drier, until, commencing in the wettest part with a *Sphagnum* bog and passing through various shrubby stages, a "tableland forest" may finally replace the bog. Below, the bog formations are treated of in what I take to be their order of development, beginning with the earliest, the *Sphagnum* bog, which for its part would originate in a lake or low-lying ground covered with water.

Sphagnum Bog.

At one time in the history of Chatham Island the *Sphagnum* bogs must have been very extensive; even when the white man first arrived *Sphagnum* must have been much more abundant than it is at present. Here and there on the tableland primitive *Sphagnum* bogs may be encountered; others of considerable extent occur in other parts of the island, of which one on the high ground between Whanga marino and Te Whanga is of great interest, but most likely even this is not by any means in its primitive condition. The *Sphagnum* bogs of the tableland usually form small islands in the midst of the second stage of bog, the *Lepyrodia* formation, described in the next section. The *Sphagnum*, perhaps an undescribed species peculiar to Chatham Island, is extremely wet, and, in the centre of the bog, pools of water lie on the surface. Walking on the surface one sinks up to the ankles, and in the centre of the bog much deeper still. Growing on the *Sphagnum*, in the very wettest places, is a small quantity of *Isolepis* sp. and *Carex* sp. Where the bog is a little drier *Hierochloe redolens*, *Poa chathamica*, and *Pratia arenaria* are

scattered about here and there. Just where the *Sphagnum* formation abuts on the *Lepyrodia* formation stunted plants of *Olearia semidentata* and *Dracophyllum paludosum*, two very characteristic plants of this latter formation, make their appearance, showing the line of tension between the two formations. Growing on the *Sphagnum* the two plants mentioned above remain very small, and often flower when only 10 cm. or less in height. Similar dwarf plants are common in peat bogs elsewhere, Professor Conway McMillan, for instance, mentioning spruce-trees in the bogs of Minnesota seventy-five years old, and but little more than 1½ in. in diameter (44, p. 460). It must have been such miniature plants of *Dracophyllum paludosum* that Buchanan referred to *Drac. rosmarinifolium* in his list of Chatham Island plants (3, p. 338).

In the bog on the Whangamarino Run the *Sphagnum* forms large rounded mounds, on which grow many plants of *Gleichenia circinata* and a few of *Pteris esculenta*. Growing in the hollows between the *Sphagnum* mounds are *Myriophyllum pedunculátum*, *Drosera binata*, *Utricularia monanthos*, *Pratia arenaria*, and *Poa chathamica*. In many places the *Sphagnum* becomes less abundant; here the soil consists of imperfectly decomposed remains of moss and other vegetable matter 1·2 cm. in depth, below which is black rather sticky peat of a fairly firm consistency. In the upper layer *Myriophyllum*, growing to a height of 4·5 cm., and forming a dense mat on the ground, stretches its rhizomes, while its roots penetrate for a distance of 5 cm. into the black peat. Growing through the *Myriophyllum* are many tufts of the *Isolepis* and *Eleocharis gracillima*. In places the *Isolepis* becomes so abundant as to almost conceal the *Myriophyllum*. At times also that extraordinary fern *Schizæa fistulosa* puts in an appearance. Where the *Sphagnum* appears the substratum is much wetter, the decayed remains of the *Sphagnum* being wringing wet. In such places *Isolepis* almost altogether replaces *Myriophyllum*. Where the ground is a little drier *Gleichenia circinata* forms an unbroken sheet; and growing in company with it are all the bog plants enumerated above, together also with many stunted plants of *Dracophyllum paludosum*, like those before described. Many of these latter tiny plants were in full bloom.

Lepyrodia-Olearia Bog.

This formation appears to follow on directly after the *Sphagnum*, so soon as the ground has become a shade drier. It is now altogether a more common formation than the *Sphagnum* proper, but it also is rapidly being destroyed, chiefly through the agency of fires. Although *Lepyrodia*

traversii itself is by no means uncommon in the northern part of the island, the formation there, although at first sight looking distinctly a primitive one, has probably been burnt, but reproduced almost unchanged. Even on the tableland there was only one small piece of this formation that I could feel sure had never been exposed to the influence of fires and stock. This is situated on the south bank of Lake Rangitapu and occupies a space of an acre or more.

The soil consists of peat completely saturated with water, into which a stout stick 2 m. in length can be thrust up to the hilt with the greatest ease. Water can be squeezed out of this soil as from a very wet sponge by quite a slight pressure of the hand. At a depth of 20 cm. the soil is rather of the consistency of porridge. So powerful is the water-holding capacity of such a soil that, if a deep drain is cut through ground such as the above, it will remain saturated with water for years right up to the margin of the drain; even the abundant natural drainage by means of many creeks flowing at a considerable depth below the surface of the peaty tableland, and having a final fall of 210 m. into the sea, have no apparent effect on reducing the water of the bogs.

The vegetation of the formation is extremely dense in most places, and consists of *Lepyrodia traversii* mixed with *Olearia semidentata* and *Dracophyllum paludosum*. In such a dense patch one has to walk right on the top of the *L. traversii*, which sinks with every step; but it is then not on the ground that one is walking, but on the *Lepyrodia* itself, while the soil is at a considerable distance beneath. In such a place *L. traversii* reaches to one's neck. Neither *O. semidentata* nor *D. paludosum* are usually quite so tall as the *Lepyrodia*, though in some places the *Dracophyllum* is the tallest of all. The lower parts of the *Dracophyllum* and the *Olearia* are usually quite leafless, owing to the density of the *Lepyrodia*. In such a dense portion there is no visible undergrowth on the wet, black, peaty ground, nothing being there but the remains of the decaying vegetation and the many matted roots. If a small hole be scooped out in this soil, it will very quickly become filled with water.

The surface of the formation is not all at one level. The *Lepyrodia*, being bent downwards either by the wind or owing to its rigidity not being sufficient to keep it upright, overlies and becomes entangled with the other shrubs, its shoots lying mostly towards the south, owing to frequently violent north winds. In places, not quite so dense as that described above, *Gleichenia circinata* puts in an appearance, its long wiry leaf-stalks raising up the laminæ to within less than 50 cm. of the surface of the vegetation. Here, or more frequently in more open places, the surface of the ground is covered with various

liverworts and mosses, especially with *Sphagnum*, a relic of the parent *Sphagnum* formation. In places where the three dominant plants are growing more thinly still, and the underlying *Sphagnum* is exposed to the light, seedlings of *Olearia* and *Dracophyllum* occur; also *Drosera binata* and *Gentiana umbellata* make their appearance, but these two latter are by no means numerous.

In some places the original *Sphagnum* is still quite thick; there the shrubby growth becomes at once much reduced, and its height quite one-half less. In such a place the sunlight can have some effect, and in consequence more plants appear. For instance, *Corysanthes macrantha* and *Carex* sp.; while *Gentiana*, *Drosera*, and *Utricularia* occur in greater numbers.

Here and there through the formation are a few stunted plants of *Phormium tenax* which have strayed from the drier ground, but which certainly do not really belong to this formation. The most important constituents of this formation are *Lepyrodia traversii*, *Olearia semidentata*, and *Dracophyllum paludosum*. Of these *Lepyrodia traversii*, a strongly marked xerophyte—as, indeed, are the other dominant plants—occurs only in very wet bogs, and a slight diminution in the wetness of the ground will cause it to disappear. It is furnished with a strong rhizome 3 cm. in diameter, which creeps through the *Sphagnum* or the peaty ground at a depth of 5 cm. From this rhizome upright rush-like shoots are given off at intervals, each bare for the lower third of its length, but above branching laterally. These upper branches are terete, dull-brown in colour, very smooth, stiff but quite flexible, and about 1 mm. to 1·5 mm. in diameter. These stems function as leaves, and are provided with a dense palisade parenchyma. A transverse section shows an irregular-shaped lacuna in the centre of the stem, surrounded by a large-celled parenchyma. This, again, is enclosed in a ring of stereome, and round the periphery is a one-layered epidermis with a very thick cuticle.* The strong rhizome is of great importance to the plant in assisting it to spread, and in so preventing the advent of other plants. Whether *L. traversii* is able to grow on dry ground like its relative *Leptocarpus simplex* only experimental culture will prove, though its structure should certainly fit it for very dry stations. Mr. Cheeseman, who first pointed out that *L. traversii* occurred in New Zealand as well as the Chatham Islands, where it was thought to be endemic, thus writes (4, p. 325): "In the Ohaupo locality *Sporadanthus*"—the genus under which the plant was then placed—"is seldom found near the margin of the swamp; but towards the centre, where there is a great depth of peat, which affords ample room for its creeping

rhizomes and long stringy roots, it occurs in immense abundance, often covering hundreds of acres to the exclusion of all other vegetation. Mr. J. Stewart, C.E., informs me that the workmen engaged in constructing the railway dreaded to encounter it, as its thick matted roots not only made it difficult to open out the drains, but were always a sure sign of a very bad part in the swamp."

Olearia semidentata varies in form according to the position in which it is growing. When it forms a constituent of the wettest portion of the *Lepyrodia* bog it is of a straggly growth, its lower part leafless and concealed by the thick mass of *Lepyrodia*, while only the ends of the branches, which project into the light, bear leaves. When growing where it has more room to spread it forms rounded bushes sometimes 85 cm. in height and 1·24 m. in breadth. Such plants, as I have pointed out elsewhere (12[8]), bear a rather close resemblance to certain cultivated species of south European *Cystus*. The leaves are variable in size, thick and coriaceous, slightly cottony and shining on their upper surfaces; but the lower surface, which alone contains stomata, is thickly covered with white tomentum. The ultimate branchlets are so dense as to touch one another. Usually the flowers of New Zealand plants are either white or yellow, but *O. semidentata* is a notable exception, the ray-florets being of the most brilliant purple (see coloured plate, 23[2], pl. ii.); indeed, a group of these shrubs covered with heads of blossom each 4 cm. in diameter is a most beautiful spectacle. The roots, which are of considerable length, project laterally, and not vertically, downwards. This manner of growth is evidently strongly hereditary, since it appears in the seedling at quite an early stage. It would be thought that a plant such as *O. semidentata*, growing under edaphic and climatic conditions of extreme constancy, would vary little. On the contrary, so far as the leaves are concerned, the amount of variation is very great. I specially measured the leaves of a considerable number of plants growing near one another in the vicinity of Lake Rangatapu. The largest measured 6·5 cm. by 1 cm., and the smallest 3·6 cm. by 7 mm. The following measurements give examples of the variability of length with regard to breadth: 6·5 cm. by 1 cm.; 5·1 cm. by 1 cm.; 4 cm. by 1 cm. The tomentum on the upper surface of the leaf varied, according to my notes, from "none" to "very abundant." The number of teeth on the margin are also very variable, both on different leaves and on the opposite sides of the same leaf, some leaves having no teeth at all and some as many as nine, while others showed all the intermediate numbers. My notes on this subject conclude thus: "Where I write, three plants

are growing side by side, which, so far as general appearance goes, might be taken for three distinct species.''

Dracophyllum paludosum, like *O. semidentata*, when growing amongst *L. traversii*, is only leafy on those stems which emerge from that latter plant. It often occupies much drier ground than even *O. semidentata*. When fully grown and under the most favourable conditions it may be about 1·8 m. in height, and is of rather a fastigiate habit.* It has long creeping woody underground stems, giving off numerous strong cord-like roots. Seedling plants also show this rhizomatous habit. This spreading of roots or underground stems near the surface of the bog is a special characteristic of bog plants all over the world, for in such a position it is possible to get the supply of oxygen for these underground organs which is so deficient in the deeper layers of the boggy peat. Professor W. F. Ganong describes how he traced a stem of *Rubus chamæmorus* in a New Brunswick peat bog for a distance of 17 ft. without finding an end (19, p. 142). The leaves of *D. paludosum* are much like those of certain other New Zealand *Dracophyllums*, being needle-shaped and stiff. They are 4 cm. long by 1 mm. broad, and have a short sheathing base. Usually they are semivertical, but sometimes almost quite vertical. The upper surface is slightly concave and the under-surface convex; both surfaces have a strong cuticle, and possess stomata. The vascular bundles are surrounded by stereome, which extends from one surface of the leaf to the other, and alternates with the chlorenchyma.

Originally the *Lepyrodia* formation must have occupied very large areas not only on the southern tableland, but on other parts of the island, especially on the low-lying ground in the north, where many relics of this formation still exist; such, for example, may be seen in abundance in the boggy ground south of Wharekauri Hill. In another part of the flat land of the north-west peninsula several acres which had evidently once been this formation were covered with young plants of *Olearia semidentata*. On these northern bogs *Cladium gunnii* is often quite common.

The xerophily of bog plants is a most astonishing phenomenon, and has received various explanations, none of which, however, seem to me altogether satisfactory. The most generally accepted at present is that of Schimper (48, p. 18), which is thus stated by Dr. Cowles (14^2, p. 145): "Schimper believes that these structures"—*i.e.*, xerophytic structures—

* Compare Kirk's remarks (42, p. 225) on *D. scoparium*, which, of course, may be the same species as the Chatham Island plant: "It is a compact plant of fastigiate conical habit of growth, exactly like that of *Cupressus sempervirens*, and quite unlike that of any other plant."

"are due to the difficult absorption in peaty soil, the humus acids and the lack of oxygen being detrimental to normal root activities. For similar reasons the normal soil activities of bacteria and fungi are lessened, and, as a result of this relative lack of decay, great quantities of peat accumulate."

Olearia-Dracophyllum Bog.

How far this may be considered a primitive formation I cannot tell, but certainly at the present time the majority of the bogs of the tableland are of this character, and it seems likely that, though all or nearly all of these have been burnt more than once, they have reproduced themselves in large measure as they originally were. On examining such an area after fire it looks at first as if *O. semidentata* was going in large measure to replace *D. paludosum;* but this appearance is more apparent than real, and depends on the more rapid growth of *Olearia*, and upon its greater distinctness of aspect, owing to its whitish leaves.

The soil of this formation is not quite so boggy as that of the *Lepyrodia* bog, therefore there must be slightly better drainage. All the same, the ground is extremely wet; water can be always wrung out of the soil, while after a shower of rain the small holes made by the hoofs of cattle and horses remain full of water for many hours.

Probably this formation originally contained a good deal of *Phormium tenax*, but that plant at present, as will be seen later on, is almost altogether absent. The undergrowth is much the same as in the *Lepyrodia* formation. The relative proportion of *Dracophyllum* and *Olearia* depends entirely upon the water-content of the soil—the wetter the bog the more plentiful the *Olearia*. Finally, when the ground becomes a little drier still, the *Olearia-Dracophyllum* bog merges into the next formation to be described, the *Phormium* bog, or, if the ground be still more dry, into the *Dracophyllum paludosum* formation, a transition between bog and forest.

Phormium Bog.

This formation, so I learnt from Mr. W. Jacobs, and could also see from its scattered remains, was at one time one of the most important bog formations of the tableland, while *P. tenax* also, in other parts of the island, was, according to Mr. A. Shand, very abundant in bogs, swamps, and even on the drier ground. At the present time a piece of primeval *Phormium* bog is almost unknown, even on the tableland. On a semi-dry ridge near Lake Rangatapu still remains a very small piece of *Phormium* bog, while all around are the blackened remains of burnt plants. Here *Phormium tenax* is easily the leading plant. Mixed with it in large quantities is *Olearia*

semidentata and *Dracophyllum paludosum*, the whole growing quite as closely as do the plants in the *Lepyrodia* bog. My notes give no list of the undergrowth; possibly in so dense a mass there could not be much.

Phormium, before it was eradicated, grew in especial profusion on the banks of the tableland streams, where the drainage would be better and the humus acids of the soil less than in the more stagnant parts of the bog. Such a stream may have the water visible in the centre of the channel, the rest of its bed being full of *Sphagnum*, while growing just in the water and on both sides of the creek are *Phormium tenax*, *Carex secta*, *Hierochloe redolens*, the whole mixed with *Dracophyllum paludosum* and *Olearia semidentata*. Growing on the *Sphagnum* is *Cotula asiatica*, *Isolepis* sp., *Poa chathamica*, and *Juncus planifolius*.

Phormium tenax of the Chatham Islands differs from the forms usually seen in New Zealand in that its leaves are not so stiff, are broader, and usually droop considerably at their extremities.

Dracophyllum paludosum Formation.

This formation seems to be a distinct transition between bog and forest. It is usually found adjacent to the forest, and consequently on the summit of a ridge, for the forest occupies the sides of gullies. The dominant plant is *Dracophyllum paludosum*, mixed with which are here and there small trees of *D. arboreum;* or juvenile plants of this latter nearly as tall as the *D. paludosum* may be abundant, and which still possess only their broad leaves. The *D. paludosum* is about 1·6 m. tall, and the shrubs so close together that one has to force them apart in walking through the formation. On the ground grows *Poa chathamica*, *Gentiana umbellata*, *Pratia arenaria*, *Pteris esculenta* (occasionally), and a few seedlings of both forms of *Dracophyllum*. Not unusually seedlings of other of the forest trees are present, and there is no reason why, when they attain a larger size, they should not destroy the adjacent *D. paludosum*. Here and there are also a few full-sized plants of *Olearia semidentata*, but in this drier ground that plant cannot compete with the *Dracophyllum*. The part most adjacent to the forest contains the greater number of *D. arboreum*, and that zone may be considered the line of tension between forest and bog.

The Tableland Forest.

Greater moisture and a more peaty soil with a great capacity for holding water seem to be the chief œcological factors which have separated this formation from the lowland

forest as a distinct plant-formation. As a proof of this we find the two trees which give the distinctive character to this forest, *Senecio huntii* and *Dracophyllum arboreum*, occurring in lowland swamps and in swampy forests, but they are almost absent from the drier ground. It is true that other Chatham Island trees also grow in swamps (see "Swamp Formation"), but they most likely are merely the plants of a line of tension between forest and swamp, and would be readily eradicated by trees better adapted for wet surroundings. Thus, *Olearia traversii*, *Corynocarpus lævigata*, and *Rhapalostylis baueri* are absent from the tableland forest; *Hymenanthera chathamica* is rare; and, with the exception of *Veronica gigantea*, the other trees of the lowland forest are much inferior in numbers to the two above-mentioned dominant species. The largest forest on Chatham Island belongs to this formation. It occupies the whole of the south-west corner of the island, extending north-wards to a line connecting Tuku and Pipitarawai. All the gullies of the tableland are also filled with this class of forest; and in some cases, these gullies becoming deep as they approach the sea, their forests are of considerable size. In most other cases the trees of the tableland gullies form merely patches or long lines. The most abundant tree of the formation under consideration is *Dracophyllum arboreum;* next comes *Senecio huntii*, which, besides occurring in the interior of the forest as a regular constituent, forms the outermost row of trees, almost to the exclusion of all others, near the line of tension between forest and bog. Such a line of *Senecio huntii* is a magnificent spectacle when the trees are covered with their masses of yellow blossoms. *Veronica gigantea* occurs also very abundantly, while the remaining forest trees, *Coprosma chathamica*, *Myrsine chathamica*, *Pseudopanax chathamica*, and *Corokia macrocarpa*, are found in smaller but still very considerable numbers. These seven trees do not by any means always occur in the proportion just stated; indeed, almost any one of them may become of more importance in the small patches of forest. The central portion of the large forest mentioned above has only quite recently been disturbed, a sheep-track having been cut through it about a year prior to my visit. This had been very little used, so, with the exception of some trifling damage by wild pigs, that part of the forest was fairly unmodified. Its trees are low, varying in height from 6 m. to 9 m., and their foliage forms a flat upper surface, as does that of the lowland forest before described, except that here and there *Dracophyllum arboreum* raises its needle-like leaves slightly above the general level. The tree-trunks are rarely straight, but lean at various angles. The soil consists of black peat with a layer of brownish humus

on its surface. Everywhere the floor of the forest is very uneven, and is covered with many dead and decaying stems of trees or tree ferns and mounds of humus. Every tree-trunk, tree-fern stem, and dead tree is covered with multitudes of filmy ferns. The lowest layer of vegetation consists of young tree ferns, especially of *Dicksonia squarrosa* and other ferns such as were enumerated before for the lowland forest. Here and there at certain seasons of the year the small red fruit-body of a fungus is abundant. The next layer of vegetation is composed of the fully grown tree ferns *Dicksonia squarrosa* and *Dicksonia antarctica*. Many of these latter are more than 4·5 m. in height, and their huge spreading fronds serve to intensify the shade of the forest and to conserve the moisture of the atmosphere. This undergrowth of tree ferns is often so dense that their stems almost touch each other. Epiphytic on the tree-fern stems are *Trichomanes venosum*, *Hymenophyllum multifidum*, *H. dilatatum*, *Trichomanes reniforme*, *Aspidium capense*, *Asplenium lucidum*, and various seedling trees. The filmy ferns are often so thick that they completely hide the trunk of tree or fern on which they grow. In many places the ground also is covered with a thick carpet of these delicate plants. In deep forest-clad gullies, where a stream at the bottom and the wet ground constantly discharge water-vapour into the air of the forest, where it is confined by the double shade of tree-tops and fern-fronds, it can readily be seen that such a gully is a station of the most intensely hygrophytic character, especially if the climate of Chatham Island, with its many morning mists and light showers, be borne in mind. In such a place, too, the wind, that factor nearly always to be reckoned with when considering New Zealand plant forms or distribution, can have but little drying influence. In such a station *Trichomanes reniforme*, the kidney fern, often grows with extreme luxuriance, the ground, fallen trees, tree-trunks, and tree-fern stems being covered with its great almost round green leaves, the younger ones of which are much brighter green and so thin as to be almost transparent. In many places this fern receives a considerable amount of sunlight; but this can do no damage, since the air which surrounds the fronds is always sufficiently moist.

It has already been pointed out what an excellent station for the welfare of seedling plants tree-fern stems offer—a very much better one, indeed, than the crowded and sometimes not too well-drained forest floor. Such seedling trees very frequently reach a large size, especially *Dracophyllum arboreum*, the roots of which plant, penetrating deeply into the soft mat of aerial roots of the fern, finally reach the ground. The plant then grows with redoubled vigour, and in the

end the tree fern, enclosed between these now very thick roots, slowly dies, and *Dracophyllum arboreum* remains in its place as a forest tree, its former roots now playing the part of a stem. Sometimes a large number of roots growing so closely together as to apparently coalesce make up such a "root-stem," to use a term from a letter of Mr. H. Carse. In one instance where a tree of *D. arboreum* had been felled while making the forest track, thus giving an opportunity for examining its structure, I counted thirty roots, which varied in thickness from 16 cm. by 7 cm. to 5 cm. by 3 cm., or even smaller, and, as seen from the above measurements, longer in one direction than the other, owing to the pressure, the whole making a "root-stem" 45 cm. in diameter. The similar behaviour of certain trees, notably of *Panax arboreum*, in the New Zealand forest is well known, and the Rev. W. Colenso has gone into the matter at considerable length so far as the Seventy-mile Bush, in Hawke's Bay, is concerned (13, p. 252, *et seq.*). Mr. H. Carse, who very kindly sent me some notes on this subject, taken in the forest near Mauku, Auckland, has written an account of this interesting matter, which I anticipate will appear in this volume, so there is no need to go into the subject at greater length here.

Dracophyllum arboreum, the dominant tree of the tableland forest, is especially interesting because of the changes which it exhibits during its life-history. In its final form it is a low tree, attaining at times a height of some 9 m. It has a short thick trunk below, and, above, spreading branches bearing masses of needle-shaped leaves, resembling much those of *Dracophyllum paludosum* before described. Besides occurring in the tableland forest, the tree is found in lowland swamps and in the drier portions of the bogs, where it marks either a retreat or advance of the present forest. The early seedling leaves are very much broader than the adult, and resemble the seedling leaves of *Dracophyllum paludosum*, which, however, are rather narrower. The early seedling form persists for a long time in the ontogeny of the individual, and young plants are quite common 1·5 m. in height possessing only the broad leaves, as shown in the photograph I took in the neighbourhood of Lake Te Kua Taupo (Plate XIX.). Usually when a plant has attained to this size it suddenly puts forth leaves of the adult type, and both leaf-forms exist upon the same individual at the same time. As the tree continues to develope all trace of seedling leaves may vanish, and finally there will be a plant merely with the needle-like leaves, looking like a very large spreading specimen of *Dracophyllum paludosum*. Usually, however, many "reversion shoots" of the most extreme

juvenile type make their appearance from any part of the tree—indeed, it is uncommon to see a tree without these "reversion shoots."

Senecio huntii, second only in importance to *Dracophyllum arboreum* as a constituent of the tableland forest, grows to about the same height as the latter. It has a stout erect trunk, varying in thickness according to the size of the tree. The trunk at a distance of 1 m., more or less, from the ground divides, giving off two or more branches, which at first spread out laterally, but finally bend upwards. These branches divide again and again into smaller ones, which always at first spread out laterally, the whole branch system from beneath looking not unlike the ribs of a huge umbrella. At the extremities of the branches are rosettes of leaves. These consist usually of from twenty to twenty-four leaves inserted so closely together that the whole occupy 2 cm. or rather more of the end of the branchlet on an average. In some cases, however, the internodes are more greatly developed; in the most extreme case measured twenty-three leaves occupied a space of 10 cm., while an opposite case gives twenty-seven leaves for 2 cm. These ultimate branches are suffruticose, and 2 cm. in diameter. The leaves themselves are lanceolate and sessile, 12 cm. long by 3·5 cm. broad in the broadest part. Their upper surface is pale, bright shining-green in colour, except where covered by a thin pellicle of whitish cobwebby tomentum. The under-surface is of a paler colour, being greyish-green, and provided with numerous short glandular hairs. The margins and adjacent portions of the leaves are often more or less recurved, thus rendering the under-surface of the leaf concave. So flexible is the leaf that it can be rolled up into a spiral from apex to base without tearing or breaking it in any way. On the under-surface of the leaf is a strong keeled midrib, which is of great importance, since it serves to maintain the rather flaccid blade in the best position with regard to the light. Each ultimate leaf-bearing or flower-bearing branchlet increases in length until it has brought its leafy portion side by side with the neighbouring rosettes of leaves; and in order to get its leaves into a suitable position with regard to the light such a branchlet is often arched first downwards and then upwards. Thus all the rosettes are brought side by side, touching but not getting in the way of each other, the whole leafy head of the tree having the form of a half-globe. Seen at a distance, the foliage of *S. huntii* forms a dense bluish hemispherical mass, which when in full bloom exhibits leaves and bright-yellow flowers in an equal proportion. The branches are extremely brittle, a sudden snap quickly breaking them; but yet they are not easily broken by the wind, their great weight of foliage notwithstanding,

since they are at the same time more or less elastic, while the suffruticose extremities of the ultimate branchlets can yield very considerably to the wind-pressure. The branches are marked with many old leaf-scars and covered with a pale bark, which is somewhat papery and readily peels off. The flower-heads are in subcorymbose panicles, pyramidal in shape, 10 cm. to 14 cm. long by 10 cm. broad through the thickest portion. Flower-stalks and involucres are densely covered with glandular hairs, which, together with those of the leaves, give out a peculiar aromatic odour to the atmosphere.

Te Awatapu Forest.

Standing on the edge of the cliffs not far from the Trig. station which marks the highest point on Chatham Island, one looks down upon a large piece of forest lying in a basin far below. This basin is formed from a great mass of the upper surface of the tableland, which, probably undermined by water, long ago fell into the sea below. In some places perpendicular cliffs, still devoid of vegetation, show whence this great mass of land must have fallen. In other places the cliffs are covered with a good deal of soil, in which is growing a luxuriant vegetation. This forest at the time of my visit was in its virgin condition. A few sheep certainly had just previously found their way down the steep cliffs, but their presence was not felt by the vegetation. Recently the forest, as mentioned in the introduction, has been opened up to stock by means of a cut track, so it seems very necessary to put on record its general appearance.

The ground of the forest consists of clay mixed with a certain proportion of peat, the clay being derived from that stratum which doubtless underlies all the tableland bogs. The surface, which as a whole slopes to the sea, from which it is separated by a jagged wall of rocks, is very uneven; the soil at the time of the landslip must have been heaped up in some places, and with corresponding hollows in others. This unevenness has also been accentuated by erosion. Through the centre of the forest a stream flows, which puts one in mind of some small New Zealand mountain torrent. This stream is fed by the never-failing supply of water from the bogs above, whence the main branch leaps down the precipitous cliffs as a waterfall.

The forest, as pointed out before, resembles in part the tableland and in part the lowland forest. It differs from the tableland forest in that it contains *Plagianthus chathamicus, Piper excelsum,* and *Rhipogonum scandens,* in large quantities; but, on the other hand, *Dracophyllum arboreum* and *Senecio huntii* are plentiful. The presence of *Coriaria ruscifolia,* here quite a tree, also separates this formation

from that of the tableland. The undergrowth of ferns is greater than I observed elsewhere on the island. *Polypodium rugulosum* with fronds 1·5 m. in length, *Aspidium oculatum* of nearly equal size, and *Lomaria procera* with fronds rather larger than either of the above, form dense masses on the steep well-drained slopes. *Asplenium bulbiferum* was extremely proliferous; on one pinna were as many as fourteen young ferns, several of which were 3·2 cm. long. Some of such young ferns had fronds 8 cm. long, with sometimes three together. This proliferous habit of *Asplenium bulbiferum* seems evoked by excessive moisture in the atmosphere, for such ferns are met with only in the dampest forests; but this has not been established experimentally as yet. Tree ferns so tall as to reach into the tree-tops are, as in all Chatham Island forests, very abundant, and, as usual, their stems have a large plant population.

The most striking feature of the forest is the enormous number of the climbing stems of *Rhipogonum scandens*. These, together with the closely growing thin liane-like stems of *Piper excelsum*, made travelling through certain parts very laborious, one having actually in many cases to crawl along the ground for considerable distances.

Besides ferns, the floor of the forest is covered in many places with the thin-leaved *Australinia pusilla*, while seedlings of the different trees are very abundant. Within the forest there are two natural ponds, and one or most likely more open spaces. The ponds, though plainly visible from the summit of the cliffs, I unfortunately missed finding, owing to the density and difficulty of the "bush."

The open space was covered with *Polypodium rugulosum* 1·4 m. tall, *Carex ternaria*(?), and *Agrostis æmula*, with *Acæna novæ-zelandiæ* climbing through the whole. Such an open space, taken in conjunction with the ponds and their surroundings, looks like a remnant of the original vegetation which first took possession of the ground after the landslip and prepared the way for forest trees. This view is supported by the fact that young trees of *Plagianthus chathamicus* are growing on the open space mentioned above, and that such a place consequently at no very distant date would, if not disturbed, become uniform with the rest of the forest.

Olearia chathamica Formation.

This formation is œcologically related to the drier phases of *O. semidentata* bog, but to what formation it is related genetically I cannot suggest. If the structure of the leaf and the general habit of the plant be taken into consideration, there seems no reason why *O. chathamica* should not share the same station with *O. semidentata*; indeed, from its larger

stature and robustness it would seem the more powerful of the two in "the struggle for existence." Be this as it may, *O. chathamica* is almost exclusively confined to the drier ground just at the edge of the cliffs, in which places *O. semidentata* is not abundant. Here *O. chathamica* forms dense thickets, unmixed for the most part with any other shrubs; or, if growing more in the open, each plant forms a large rounded bush. The branches radiate upwards and outwards from usually several short thick main stems, and are leafy only at their extremities for a distance of about 18 cm. or so. Their ultimate branches are covered with dense white pubescence. The leaves vary in shape, some being merely lanceolate, but others much broader. On the upper surface they are of a vivid green, and either glabrous or show the remains of a pellicle of tomentum; on the under-surface they are exceedingly tomentose with white tomentum. A transverse section of a leaf shows an extreme xerophytic structure—viz., a thick cuticle on the upper surface, a two-layered epidermis, four rows of very close palisade parenchyma of much greater breadth than the spongy parenchyma, strong stereome round the vascular bundles, and the stomata on the under-surface of the leaf protected by the densely interwoven hairs. The leaves spread out horizontally, but point a little upwards.

Growing underneath the plants of *O. chathamica* is a variable amount of vegetation, consisting of *Lomaria procera*, *Hydrocotyle* sp., *Uncinia* sp., *Pteris esculenta*, and here and there a young tree fern. Mr. W. Jacobs tells me that *Phormium tenax* used to grow abundantly amongst the *Olearia chathamica*, and that probably the shrubs which I was examining, now 1 m. to 2 m. in height, are simply a new growth since a first burning, perhaps twenty years ago or more. Whether this is so or not, there is at the present time a distinct zone of *O. chathamica* extending for a distance of 12 m. or more along the south cliffs of Chatham Island, and following the dry ridges inland, but usually only for a short distance; and there are no traces of this formation elsewhere in the island, except that an isolated plant or two have been found on his run by Mr. Cox. In the north of the island *O. chathamica* is altogether absent. On Pitt Island it is represented by the very closely allied species or variety which I am naming *dendyi*, and which has purple and not white flowers, and a different kind of tomentum on the under-surface of the leaf.

Tableland Dry Ridges.

The word "dry" is used merely as a comparative term to distinguish the soil of this formation from that of the wet bogs; but it is only dry insomuch as, although very moist, water cannot be squeezed out of it. The summits of many

tableland ridges are covered with this formation, and it seems probable that much of the bracken-covered ridges of other parts of the island was originally of this nature. Whether the formation is almost a primitive one or whether it has become considerably modified I cannot say; probably at one time it contained a good deal of *Phormium tenax*.

The most characteristic plant is *Cyathodes robusta*. This forms large rounded bushes of considerably greater breadth than height, with the leaves all touching, and forming quite a dense mass. The leaves are 15 mm. long by 3 mm. broad, more or less, stiff, coriaceous, green on upper surface, but with the under-surface marked with parallel ridges separating about nine furrows, which are covered with wax. The drupes are large and very abundant; on some bushes they are red and on others white, when ripe. The bushes of *C. robusta* are situated at some distance apart, and growing in the open ground between them are tussocks of *Uncinia* sp.; *Gentiana pleurogynoides* var. *umbellata; Acæna novæ-zelandiæ; Gnaphalium filicaule*, forming large round silvery patches after the manner of the *Raoulias* of New Zealand river-beds; *Lomaria procera; Hydrocotyle asiatica; Pteris incisa; Pteris esculenta; Lagenophora forsteri; Luzula* sp.; *Pratia arenaria*.

The ridges on which this formation occurs are much exposed to the wind, which may account for the ball-like shape of the *Cyathodes*. Growing close to the *Cyathodes* formation on one ridge examined was a small patch of trees of *Coprosma chathamica, Myrsine chathamica*, and *Corokia macrocarpa;* while at the margins of the formation the vegetation became mixed with *Dracophyllum paludosum* and *D. arboreum*. It seems from this that here, as in the bracken formation of the lowland, wind is the factor which decides whether forest shall take final possession of the soil. There are certainly a number of plants in this formation which are not included in my notes, but here, as elsewhere, only those are quoted which were actually written down, and throughout this paper no exhaustive list of plants is anywhere attempted.

Rock.

Leaving out of the question the mosses, the lichens, and those other cryptogams which are the first plants to clothe the naked rock, and consequently a most primitive plant-formation, the phanerogams and ferns which inhabit unshaded rocks are only such as, aided by special xerophytic adaptations, can tolerate a position of such extreme dryness. They usually consist of such plants as can be brought readily by birds or wind. Some of these come doubtless at first as mere casual visitors, but, being able to maintain themselves by various

temporary adaptations, have stayed, and in the course of many generations have become specially differentiated for the rock life. Others, again, belonging naturally to xerophytic stations, may have been driven on to rocks by certain aggressive plants, which have ousted them from their original position. The study of such matters as this latter is, with regard to New Zealand plants, in its infancy, and little can be said of any scientific value. Chatham Island, however, furnishes one very interesting case where a plant once very abundant is almost driven from its principal stations, and will before many years be found only in two places of the most opposite character—viz., rocks and margins of lakes. From what has gone before it may readily be guessed that I allude to *Phormium tenax*. How its destruction has come about and how it has settled in its new quarters will be explained in another section. I need only say here that, although in this case human influence has been the chief agent, how can one tell that such also has not been a determining factor in bringing about certain local distributions of plants in the Old World? Also, it is well known that without human agency of any kind one plant can replace another.

The cone-like volcanic hills have in some instances rocky summits. On such bare volcanic rock grow the orchid *Earina autumnalis* and the very thick-leaved fern *Polypodium serpens*, both of which are also epiphytes of the forest. The decay of the earlier lichens and mosses paves the way for this later vegetation. In such vegetable matter on the perpendicular side of Maunganui Hill grows a short-leaved form of *Asplenium flaccidum* in company with *Polypodium serpens*. The roots of the *Asplenium* are densely covered with hairs, and form a mat spread out for a distance of 15 cm. No station much more dry can be conceived than the face of such a perpendicular volcanic rock. Of course, in wet weather the decayed vegetable matter will absorb water readily, but at the time of examination it was as dry as dust, and certainly the plants would not be able to absorb any moisture from it whatsoever. Under such circumstances these plants must depend entirely upon the water stored up in their thick leaves. On the summit of another rock near by I saw a number of both young and old forest trees, the latter much stunted, growing in peat, then quite dry, of not more than 20 cm. depth.

The Horns is the name given to a volcanic hill at the south-west corner of the island, and which receives its name from there being two rocky cones rising close to one another, and much of the same height. On the steep rocky face of the more easterly horn are growing *Phormium tenax*, *Polypodium billardieri*, *Veronica* sp. (neither *V. dieffenbachii* nor *V. chathamica*), *Muhlenbeckia adpressa*, *Linum monogynum*

var. *chathamicum*, *Cyathodes robusta*, *Pteris esculenta*, *Olearia chathamica*, and a form of *Coprosma propinqua*, this latter being a most remarkable plant. As usually seen in Chatham Island it is the principal constituent of one part of the swamp formation; but here, if the species be the same, it is a prostrate shrub with long, trailing, slender branches, which in places send down adventitious roots into the rock-crevices. The whole plant is flattened close against the rock; indeed, it bears no resemblance at all to the erect bushy swamp plant. In certain of the bogs also what I took to be the same form of this species of *Coprosma* assumes a trailing habit not unlike the rock form just described. The *Muhlenbeckia* mentioned above was growing over the *Coprosma*, and to some extent they would mutually protect one another from the wind. How far this peculiar adaptation to the rock mode of life is fixed, or if it is merely the effect of wind, &c., and is not hereditary, I cannot say. The plants secured for testing this question unfortunately died.

It is on the cliffs of the south coast that the richest rock vegetation of Chatham Island is to be found. Here a good deal of accumulated vegetable matter and soil in places, great unevenness of surface, and a south aspect promoting moisture, with much soakage from the wet tableland, have given far more favourable conditions for vegetation, with the consequence that the greater part of the coast cliffs are clothed with a beautiful green mantle. This covering is closely related to the tableland forest, but, owing partly to the greater amount of light which can penetrate the vegetation, some of the other plants of the tableland are abundant, notably *Phormium tenax* and *Olearia chathamica*.

EFFECT OF INTRODUCED ANIMALS ON THE PLANT-COVERING.*

As I have suggested when speaking of the aborigines, very little change would be wrought in the vegetation of the island by either Moriori or Maori. They would have little object in setting fire to large tracts of country; and, even in case of such being burnt, there would be neither the foreign plant nor animal factor to cause a marked change in the reproduced vegetation. Even at the present time it is almost impossible to discriminate between a piece of bog vegetation which has been burnt many years ago and a piece of the primitive formation. It may therefore be assumed that, to all intents and purposes, the plant-covering of the island at the time of the advent of the missionaries was precisely as it had been for

* In connection with this, and with the effect of burning on the vegetation of New Zealand, the interesting paper of Canon Walsh may be studied (53).

a very long period. But as the animals which were introduced increased in number and spread over the entire island a very different state of affairs arose for the indigenous plants. They too, like the Moriori, had been long isolated, and the various species had become finally differentiated without any regard to the attacks of grazing animals. Cattle and horses roaming over the sand-dunes would loosen the sand, and also feed in many instances on those plants which bound the sand together.

There are few balances more finely adjusted than that between sand blown inland and its fixation by plants. Once disturb that balance, no matter how slight the disturbance may be, the equilibrium will be destroyed, and the resistance of the sand-binding plants overcome. Thus the destruction of a few plants growing on the dry sand of the shore just above high-water mark, the great source from which all inland-blown sand arises, will increase the volume of wind-driven sand against which the dune plants have to contend.

In Chatham Island, as pointed out before, quite a number of plants grew on this upper strand, conspicuous amongst which was the majestic forget-me-not *Myosotidium nobile*. The leaves of this plant are much relished by sheep, and so, as the settlements of both white man and Maori are usually near the coast, this plant would very early on be attacked. Not only do sheep eat the leaves, but pigs dig up and feed on the great rhizomes, with the natural consequence that the endemic *M. nobile*, one of the most magnificent and interesting plants in the world, is now all but extinct in the wild state. A few plants still exist on the north coast of the island, notably near Matarakau and Waikauia, and there are a few in the neighbourhood of Red Bluff, while below Te Awatapu there is a bed of plants still in its virgin state; but the long line of this plant on the sea-shore, with its huge shining green leaves and great heads of blue flowers, is lost to the world for ever. Happily the plant is very amenable to cultivation in favourable localities, and almost every settler's garden contains some fine examples. Were a piece of ground fenced in from sheep, &c., the plant would again reappear, as in the case of an old Moriori grave-yard fenced in by its owner, Mr. H. Grennel, and described by Professor A. Dendy in a paper read at a recent meeting of our Institute (15). The sand, no longer held by the strand plants, blew inland, became piled up against the dune forests, and, gradually accumulating and advancing inland, it finally buried them, so that now, instead of a fringe of trees all round the sandy parts of the coast, there are high moving dunes in many places.

In the forest cattle and horses eat the foliage and bark of the trees, at the same time breaking down the undergrowth and

the lianes. I was much struck when first examining Chatham Island forests by their want of undergrowth and lianes, which did not accord at all with Travers's description when writing of the Moreroa Bush, thus: "The whole so interwoven with our old friend the supplejack as to be almost impenetrable" (51, p. 176). However, when visiting the Te Awatapu Forest I saw clearly that the lowland forests were no longer in their primitive condition. Messrs. Chudleigh, Shand, and Cox have also all assured me that the forests were formerly very much denser and lianes more abundant than is now the case. In addition, at the present time the forest on the Horns is undergoing an early stage of destruction by cattle, which have only reached that part of the island recently. Almost everywhere are trees broken or, in the case of *Piper excelsum*, uprooted, while the ground is much trodden and seedling trees and young ferns destroyed.

Another change which concerns the proportional representation of species in a forest-formation is destruction of certain trees through animals eating the bark. *Pseudopanax chathamicus*, *Plagianthus chathamicus*,* and *Coprosma chathamica* very often suffer through this cause. Such trees being destroyed, others easily and rapidly produced from seed take their places, and so are now more numerous than formerly. Mr. W. Jacobs tells me that, owing to this cause, the constituent trees of the Moreroa Forest no longer exist in the same proportion as they did twenty years ago. Certain plants have been almost eradicated by grazing and uprooting. The case of *Myosotidium nobile* has been already referred to. *Aciphylla traversii*, another very characteristic Chatham Island plant, is now very scarce. Its leaves are greedily eaten by sheep, and its thick tap-root is devoured by pigs. At the present time isolated plants may be found in boggy ground in all parts of the island, but large areas may be traversed without encountering a plant. Even in the fairly primeval tableland district it only exists in any quantity on the steep banks of some of the small lakes which are not easily reached by stock. *Veronica dieffenbachii* and the other forms of *Veronica* closely allied to that species are, according to Mr. Cox, greedily eaten by sheep. These *Veronicas*, in consequence, are now confined to rocks and banks of creeks or lakes; doubtless at one time they were much more plentiful. It is probable also that the great sowthistle, *Sonchus grandifolius*, found now chiefly in places inaccessible to stock, was at one time much more abundant on the sand-dunes; but I have no proof as to

* This plant is also destroyed by the settlers, who at times use the bark for making hats. The same remark also applies to the palm. Other trees, especially *Olearia traversii* and *Pseudopanax chathamica*, are cut down for fencing-posts and firewood.

whether it has been reduced through being eaten by stock or through instability of the dunes. At any rate, either cause can be traced to the advent of domestic animals.

Besides changing the vegetation through feeding upon it, horses and cattle have also had a very great influence on the water-content of the soil. Wandering over the swampy and boggy ground in search of the food which was originally very plentiful there, they gradually consolidated the surface of the ground. By this means many of the swamps of the island have been turned into rich grazing land. The racecourse at Waitangi is an excellent example, and such "reclamation" of ground by grazing animals can be observed in every state of progress from quite dry meadow to almost primeval swamp. In this particular instance, too, the effect of the final close cropping of the herbage by sheep may be observed, and the change wrought by this on the vegetation estimated. Certain plants which formerly did not form any large percentage of the original vegetation, or which were altogether absent, now make up the meadow land of the racecourse and the ground between the low forest and sand-dunes from Waitangi to Te One. On this piece of ground sheep in very large numbers are constantly grazing, and yet the present vegetation manages easily to hold its own, and has entirely replaced that of the original swamp, which must in large measure have been similar to that described under the heading "Swamp Formation." The plants consist almost entirely of those which possess a far-reaching and rapidly growing prostrate or subterranean stem-system, which, through the great power of vegetative increase which it gives, the abundant food-supply which it contains, and its being secure from damage, enables its possessors easily to resist the attacks of grazing animals. At present the Waitangi Racecourse is a flat meadow marked with many small hillocks or unevennesses, which proclaim the presence of former clumps of swamp vegetation. Everywhere the ground is covered with a thick turf. This is composed of *Crantzia lineata* in very large quantities; also *Pratia arenaria*, the introduced *Poa pratensis*, a small species of *Juncus*, *Potentilla anserina*, all in large quantities; *Hydrocotyle asiatica* abundant, but hardly so much so as the preceding; a variety of *Epilobium cæspitosum*, *Myriophyllum pedunculatum*, *Lagenophora forsteri*, *Eleocharis gracillima*, and *Gnaphalium collinum*, also fairly plentiful. On the driest portions of the hillocks is abundance of *Gnaphalium filicaule*. The whole of these plants have stems which are either underground or creep close to the surface, and several, as we have seen, have great powers of adaptation either to wet or dry conditions of soil. Also, some may not be much eaten by sheep, but it is significant that the two which are especially

abundant, *Crantzia lineata* and *Pratia arenaria*, are considered by Chatham Island sheep-farmers* most valuable pasture plants; and there seems little doubt that these two plants at any rate, owing to former plant adversaries having been removed, partly through changed edaphic conditions and partly through close grazing by animals, have become very much more abundant in Chatham Island generally than was formerly the case—helped, of course, by the great vegetative increase of their stems rendering them safe from the attacks of sheep. But if a plant be isolated and there is no other food for the grazing animals it may not be able to hold its own. Thus *Poa chathamica*, notwithstanding its strong wire-like rhizome, cannot resist close grazing on the tableland bogs, where no other food is present for the hungry animals, and it may be eradicated for a time.

Besides domestic animals, certain European birds have been brought over to the island, and others, strange to say, amongst which are the sparrow and blackbird, are said to have made their way from New Zealand unaided. Such birds play a much more prominent part with regard to the introduced than to the indigenous vegetation, doing a great deal of damage to the crops and gardens of the farmer. They also carry and distribute the seeds of both native and introduced plants; in this case, as pointed out before, doing the work of the former indigenous birds, which now for the most part have become very limited in number. Perhaps the greatest work such birds are performing is that of spreading the blackberry all over the island, but this matter concerns the next section.

As for the effect of introduced insects, I procured no information; probably the hive bee plays an important part in fertilising certain of the introduced plants, and so causing their spread.

EFFECT OF INTRODUCED PLANTS.†

With regard to the influence of introduced plants on the vegetation of Chatham Island I can say little, the time at my disposal not permitting me to collect examples, or even make a list of the species. Mr. T. Kirk published a list of those introduced plants which Travers collected (35), but it contains only twenty-eight species. Probably there were even then

* Mr. E. R. Chudleigh, for instance.

† On the importance of this subject Mr. Hemsley, speaking of the work of the late Mr. T. Kirk (38), writes in *Nature* (27): "He"—Mr. Kirk—"has put on record facts connected with the introduction and colonisation of exotic plants in New Zealand that positively throw a new light and suggest new ideas on the present distribution of plants in cultivated countries generally."

a great many more, and most certainly others must have put in an appearance during a period of more than thirty years. All the same, speaking generally, I do not think introduced plants have taken possession of the soil to anything like the same extent as in both Islands of New Zealand. When Chatham Island vegetation is destroyed by fire or cultivation, thus making way for introduced plants, it is certain indigenous plants which have become weeds rather than those which are introduced. For example, *Acæna novæ-zelandiæ* now abounds everywhere, becoming an actual torment to the pedestrian during certain seasons of the year, one's lower garments becoming completely concealed in a few minutes with a dense brown mass of its barbed fruits. Again, the extremely wet character of the soil is antagonistic to the spread of many of those plants which have replaced the vegetation of New Zealand; while, on the other hand, the shade of the forest demands special adaptations from those plants which seek to get a foothold.* Certain plants, however, have spread very considerably. Of such the blackberry (*Rubus fruticosus*) seems to be the only one which is a menace to any large proportion of indigenous plants. At first it was planted for hedges; but these hedges have now exceeded all bounds and are hedges no longer, but dense thickets. Were this all little harm would accrue, but through the agency of introduced birds the plant is spreading all over the island, especially within the forest areas. I noticed seedling plants in many places, even in the partly primitive tableland forests. On the banks of the Waitangi River are enormous thickets which hang right down into the water; indeed, in certain places considerable areas are occupied by this plant, and the original vegetation is entirely replaced. It is possible, if the spread of this plant is not checked in some manner or another, it may destroy the forest undergrowth entirely, as well as seize on large areas of open ground.

Poa pratensis is much valued in Chatham Island as a pasture grass; it has spread considerably in many places, and has even taken possession of certain stable sand-dunes, covering them with a turf. In wet meadows, such as the

* Introduced plants spread especially where the indigenous vegetation has been more or less disturbed. Where the plant-covering of a region is in its virgin condition, and there is nothing to bring any introduced plants except the wind, they often fail to become established. Thus Mr. T. F. Cheeseman saw only two naturalised species on the summit of Pirongia Mountain (5, p. 321), and these, he writes, "had in all probability been accidentally brought by the surveyors." At the source of the River Poulter, in Canterbury, South Island of New Zealand, I saw no introduced plants of any kind in places where man, sheep, or fires had never been, although such country was fully exposed to the north-west wind, which must bring many light "seeds" from Westland (12).

racecourse before described, although it has become a distinct component of that recent plant-formation, it is no more dominant than some of its indigenous competitors. On dry slopes, where fires are constantly opening up room for the advent of introduced xerophytes, none have yet arrived which can make the slightest headway against *Pteris esculenta.*

Certain other causes distinctly operate in checking the spread of introduced plants, amongst which may be mentioned—the small area of cultivated land; the absence usually of roads, there being merely horse-tracks over the greater part of the island; the small amount of traffic with other countries; and, finally, the large number of sheep which graze on such land as introduced plants could best establish themselves on.

EFFECT OF FIRES ON THE PLANT-COVERING.

Of all the factors which have changed the plant physiognomy of Chatham Island, fires have been by far the most important. In order to provide young growths of grass for his sheep, the farmer sets fire to the bracken fern of the heath or the *Dracophyllum* of the bog. Such fires in dry weather spread over very large areas, and the whole of the vegetation is burnt right down to the ground, leaving only the blackened bases of the plants. This destruction leads to the spreading of certain plants which had been kept in check by others. It also leads indirectly, especially when aided by the trampling of stock, to the drying up of the ground in wet places.

Of all the plants which gain an ascendency after burning none can approach *Pteris esculenta.* As burning succeeds burning so does the *Pteris* increase, until at the present time it must occupy a very much larger area than it did originally; indeed, it seems to me hardly an exaggeration to affirm that it occupies ten times its original area. In this opinion I am supported by Mr. E. R. Chudleigh, who tells me that "bracken has increased enormously since the advent of the white man, and, owing to burning, stocking, and other causes, it has replaced much of the original vegetation." Even after burning the *Sphagnum* formation bracken takes the place of *Gleichenia circinata,* and with repeated burnings the *Sphagnum* altogether disappears and the ground becomes dry and covered with a thick mantle of bracken. Mr. D. Petrie also writes (50, p. 323), speaking of the spread of certain plants in the Auckland Province: "The most aggressive plant of all is *Pteris aquilina,* which is rapidly overrunning much of the land that has been cleared of bush, and which permanently establishes itself before roots are sufficiently decayed to admit of ploughing."

It is only by studying the plant-formations of the table-

land that the change wrought by constant burning can be properly estimated. Nor is it burning alone, as already pointed out, which brings about changes in the vegetation, but rather burning *plus* the attacks and trampling of animals. As to the effect of these two causes combined upon the plant-covering, no plant is so instructive as *Phormium tenax*. This, once extremely common nearly all over "the clears" of Chatham Island, as shown before is now almost extinct. How this came about seems worthy of a detailed explanation, since misstatements regarding the causes which lead to the eradication of *P. tenax* have been circulated so often as to be accepted by the scientific world as fact. Thus Wallace writes: "White-clover (*Trifolium repens*) spreads over all the temperate regions of the world, and in New Zealand is exterminating many native species, including even the native flax (*Phormium tenax*), a large plant with iris-like leaves, 5 ft. or 6 ft. high" (52, p. 29).

If we consider the stations in New Zealand where *P. tenax* grows, we find that in several of them white-clover can only grow with difficulty or not at all. Such are rocks, very dry river-terraces, sand-dunes, and very wet swamps, this latter a most characteristic station. Moreover, the reclaimed *Phormium* swamps in which white-clover is now established and *Phormium* eradicated have usually been artificially drained, and the *Phormium* itself constantly set fire to, thus bringing about a very different state of affairs for the white-clover to become established than an undrained swamp.

But the introduced-plant factor and the fire factor would be of no avail to destroy *Phormium* and lead to its replacement by a comparatively insignificant plant did not stock eat its leaves with avidity, especially the young and comparatively tender ones which spring from its rhizome after burning, with the result that, the growing-point being destroyed again and again, the rhizome finally rots and the plant dies. This is what has happened to the *Phormium* in Chatham Island. After fire its succulent leaves are almost the only food available for the hungry stock; they are eaten and the plant perishes. So also every seedling that cannot establish itself out of harm's way is destroyed. In the lowland swamps, out of reach of the stock, young plants of *Phormium* may be occasionally seen on the stems of *Carex secta*. With the draining of the swamps that haven of refuge will be gone, and *Phormium* will only be met with on rocks and in shallow lakes, where under the two opposite conditions there seems every chance for two new species being evolved.

In the place where *Phormium* originally grew there is no reason why white-clover, or any plant whatsoever that can maintain itself against other competitors, should not re-

people the ground; but this is certainly not an example of one plant exterminating and so replacing another. As an example of the power of *Phormium* growing in ordinary soil to resist aggression, a plant in my garden has grown luxuriantly for nine years in ground which is a complete mat of the rhizomes of *Triticum repens*, almost the most aggressive introduced garden weed with which I am acquainted.

To give an exact account of the changes which come about in a plant-formation after repeated burnings would require close observation extending over a considerable period of time. All that my limited stay on Chatham Island permitted was the examination in a number of places of vegetation reproduced after fire growing by the side of portions of original vegetation, or of a vegetation burned at an earlier date, as the case might be. The following are extracts from my notes on this matter :—

(a.) "Clear" in Forest at South-west of Island; burned about fifteen months.—Such an open spot as this is probably the remains of a bog once much more extensive, but which is now nearly all replaced by forest. Everywhere the blackened stumps and burnt shrubs are standing, while in the wettest ground the burnt *Sphagnum* forms large round hummocks. The original vegetation was *Olearia semidentata*, *Lepyrodia traversii*, and *Dracophyllum paludosum*, with the characteristic undergrowth of this particular plant-formation. In the driest places are *Lomaria procera*, *Lepyrodia traversii* 15 cm. tall from old rhizome, and also seedlings 3 cm. tall, seedlings of *O. semidentata* 8 cm. tall, and *D. paludosum* seedlings 1 cm. tall. In the moister places towards the centre of the "clear" are *Carex* sp., often forming large green masses, *Gleichenia circinata*, *Lepyrodia traversii*, *Drosera binata*, and seedlings of the *Dracophyllum* and *Olearia* as before. The *Dracophyllum* seedlings are so close together as to touch one another. In 20 cm. by 20 cm. of ground are twenty *Carex* sp. + one hundred *D. paludosum* + nine *O. semidentata* + forty stems of *L. traversii* + one *Gleichenia circinata*, but the *Olearia*, being much larger than the *Dracophyllum*, is more conspicuous in the formation generally. From the above it seems that in this case a formation closely akin to the *Lepyrodia* formation will replace the original pure *Sphagnum* formation, while in other parts perhaps there will be little change.

(b.) Boggy Ground near Lake Te Kua Taupo; vegetation burnt three years ago.—From the remains of the burnt vegetation still standing it can be seen to have originally consisted of *Olearia semidentata* 1·8 m. tall, and *Dracophyllum paludosum* perhaps hardly so tall, and probably with the undergrowth common to such a combination. The reproduced

plants on the wettest portion of the ground are *O. semidentata* 35 cm. tall, sometimes in clumps of three or more, and 1 m. or 2 m. apart. Between the *Olearias* is a carpet of *Cotula asiatica*, tussocks of *Uncinia* sp., *Epilobium novæ-zelandiæ(?)*, *Acæna novæ-zelandiæ*, *Pratia arenaria* in very large quantities, and *Marchantia* sp. Here and there *Pteris esculenta* and *Gentiana pleurogynoides* var. *umbellata* are on the driest places. On the still drier ground the vegetation originally consisted of *D. paludosum* and *O. semidentata* 1 m. or so in height, and in about equal proportions. The present vegetation is *O. semidentata*, 20 cm. tall and nearly as much through, and vast numbers of *D. paludosum*, while nearly the whole ground is green with *Pteris esculenta* and *Gleichenia circinata*. Where bare patches not seized on by the above ferns occur are *Pratia arenaria*, *Gentiana umbellata*, *Isolepis* sp., and *Cotula asiatica*. In the moister hollows of the drier ground *O. semidentata* is in greater number, while the green carpet of ferns is entirely absent, and in its stead is *Carex* sp., a little *Lomaria procera*, and a smaller quantity of *Lepyrodia traversii*. On the driest part the fern is quite 23 cm. tall, and covers the *Dracophyllum* seedlings. This is a very instructive list, and shows clearly how greatly *Gleichenia*, and especially *Pteris esculenta*, increase after fire. The increase of *Pratia arenaria* is also important. Were a number of hungry cattle to wander for a time over such a burnt tract there would be little chance of the original bog vegetation ever returning, while the fern would increase in power.

(c.) Boggy Ground formerly occupied by Phormium tenax + Dracophyllum paludosum + Lepyrodia traversii + Olearia semidentata + Lomaria procera; burnt perhaps eighteen months before.—The new vegetation consists of *O. semidentata* and *D. paludosum* seedlings in abundance, *Carex* sp., *Gleichenia circinata*, *Drosera binata*, *Utricularia monanthos*, *Lepyrodia traversii*, *Lomaria procera*. Here no more *Phormium* has appeared, and *Gleichenia* is in greater abundance than formerly.

(d.) Hollow near Lake Rangatapu formerly occupied by Olearia-Dracophyllum Formation, and burnt quite recently.—The ground is fairly firm on the surface, but it is a quagmire below, and water can be wrung out of the surface-soil. The ground is rapidly becoming covered with a green carpet of plants 3 cm. or less in height: *Gleichenia circinata* is everywhere; so are innumerable seedlings of *Dracophyllum paludosum* with ten leaves, more or less, 1 cm. to 1·5 cm. tall, and with one or two branches from the base. *Olearia semidentata* is not so abundant as the *Dracophyllum*, but 11 cm. tall. *Carex* sp. is extremely abund-

ant, and about the same height as the *Olearia*. *Lepyrodia traversii* is reappearing, but to much less extent than in the original formation. *Gentiana umbellata* is more plentiful than before. Finally, there is a certain amount of *Drosera binata*, *Utricularia*, *Pratia arenaria*, and *Isolepis* sp.

(e.) Dry Ridge near Lake Rangatapu; burning quite recent.—Original vegetation, *Phormium tenax*, *Dracophyllum arboreum* and *D. paludosum*, *Cyathodes robusta;* undergrowth of *Lomaria procera*, *Luzula* sp. in large quantities, *Pteris esculenta*, *Gnaphalium filicaule*. The reproduced vegetation consists of *Pteris esculenta*, *Hydrocotyle moschata*, *Gentiana umbellata*, *Erechtites* sp., *Gnaphalium luteo-album*, *Lomaria procera*, *Acæna novæ-zelandiæ*, *Epilobium novæ-zelandiæ*.

(f.) Burnt Forest.—It is almost unknown for forest to be burnt in Chatham Island, but this was an isolated patch round which the bog fire must have raged furiously Where the forest stood is now one dense mass of tree ferns coming into leaf.

(g.) Burnt Vegetation of Tableland Dry Ridges.—On the very driest ground, where formerly *Cyathodes robusta* was the leading plant, the vegetation of which has probably been burned several times, *Pteris esculenta* is very abundant. Also in fair numbers are *Dracophyllum paludosum* seedlings, *Lomaria procera*, *Epilobium pedunculare*, *Acæna novæ-zelandiæ*, *Luzula* sp.

(h.) Piece of Vegetation near Lake Te Kua Taupo; probably burnt only once, and that many years ago.—*Dracophyllum paludosum*, 38 cm. tall, forms to the eye the almost entire vegetation, except for here and there a few plants of *Olearia semidentata* of nearly the same height. All the plants of *D. paludosum* grow very closely together, but here and there are small patches where *Dracophyllum* is absent. In such places *Gleichenia circinata* 21 cm. tall, mixed with a small quantity of *Pteris esculenta*, is present. Where the *Gleichenia* is lower and without any dead fronds at its base the bare black soil becomes exposed, and in it are growing *Caladenia bifolia* and *Gentiana umbellata*. On one patch 59 cm. by 29 cm. are fifteen plants of the orchid and four of the gentian. Often through the tall *Gleichenia* a few plants of *Dracophyllum* emerge for a distance of 12 cm. The ground in which the *Dracophyllum* is growing is covered for a depth of perhaps 2 cm. with shed leaves, growing amongst which is *Pratia arenaria*. In places a little *Gnaphalium filicaule* is present, and in some of the open patches *Pteris esculenta* is more abundant than *Gleichenia circinata*. In the largest open patches *Uncinia* sp. and *Acæna novæ-zelandiæ* are present; also *Gentiana umbel-*

lata, *Pratia arenaria*, and *Lomaria procera*. Such an open place of 1·25 square metres has *Gleichenia* scattered through it, a few plants of *Dracophyllum paludosum*, one plant of *Uncinia* sp., abundance of *Lomaria procera* 2 cm. or 3 cm. tall, seven plants of *Gentiana umbellata*, some *Acæna* and *Pratia*, a few plants of *Caladenia*, *Epilobium novæ-zelandiæ*(?), two plants of *Luzula* sp. Wherever the ground is more boggy *Olearia semidentata* becomes more abundant and *Lepyrodia* appears. Here also *Carex* sp. puts in an appearance.

(*i.*) *Example of Reproduction after burning twice.*—Where the recent formation described under the heading (*h*) has been burnt we have an example of reproduction of bog vegetation after two burnings. The ground is not so boggy as in the original bog, although it sinks slightly when trodden upon. Here the principal vegetation is a carpet of *Gleichenia circinata* mixed with *Pteris esculenta* 75 cm. tall. There is more of the *Gleichenia* than of the *Pteris*. All over the ground are the burnt dead stems of *D. paludosum*. Here and there the fire has missed a few patches of secondary *Lepyrodia-Dracophyllum* formation. Through the *Gleichenia* projects *Poa chathamica*, *Lomaria procera*, and *Gentiana umbellata*. On the barer spots, where the fern is absent, occur numerous seedlings of *Dracophyllum paludosum* about 6 cm. tall. In other places, on bare spots, are *Cotula asiatica*, *Caladenia bifolia*, *Drosera binata*, *Utricularia monanthos*, *Epilobium novæ-zelandiæ*(?), and *Pratia arenaria*. In some places seedlings of *D. paludosum* are very numerous—*e.g.*, on a piece of ground 32 cm. by 25 cm. are sixty plants of various sizes.

(*k.*) *Plants occurring immediately after burning Pteris esculenta on the Ridge between the River Makara and the River Awainga; the bracken here must have been burnt many times.*—The fern had been burnt very recently, and new growth of other plants was just commencing. The chief plants appearing were *Gnaphalium filicaule*, the first plant of all to appear; *Luzula*; *Acæna novæ-zelandiæ*; *Hydrocotyle asiatica*; *Ranunculus plebeius*; *Microtis porrifolia*; *Pratia arenaria*.

(*l.*) Where two or three burnings have taken place on a boggy flat piece of ground a mile or so to the south of Lake Rangatapu *Poa chathamica* was growing in tufts 15 cm. or less apart, the whole ground looking not unlike a field of oats. The culms were 58 cm. tall, and in each tuft were twelve to twenty leaves each 20 cm. in length. Mr. Cox, who was with me at the time, had never seen this grass growing in such profusion before, and was much struck with its evident capability of being used as a fodder plant on very boggy country.

Speaking generally, the following seem some of the most

important effects of fire upon the vegetation of Chatham Island :—

(1.) Small plants which in the original formation are prevented from spreading get a foothold, and at first, at any rate, form a much larger proportion of the vegetation than formerly.

(2.) The ground, being exposed to wind and sun, gets drier on the surface, and so becomes occupied by plants which could not thrive so well on the wetter ground, consequently the plants of the wetter ground become fewer in number. Thus repeated burnings substitute *Dracophyllum paludosum* for *Olearia semidentata*, while at the same time *Gleichenia circinata* and *Pteris esculenta* increase in quantity.

(3.) The ground being cleared of vegetation allows the inroad of grazing animals, which consolidate the ground and feed upon certain plants, which consequently decrease, while others untouched will increase. This leads finally to the destruction of certain plants altogether, such as *Phormium tenax*, as before mentioned. On the other hand, the *Uncinia* is not touched at all by stock, and it increases very considerably, especially on the outskirts of forests; but *Pteris esculenta* increases most of all.

(4.) One or two burnings may make very little change indeed in the vegetation of a bog, so that after a lapse of many years it is quite impossible to tell whether such a formation has been burnt at all; and it is, moreover, very likely that the early changes after a first or even a second fire may not be permanent, and that the original formation may be to all intents and purposes reproduced. But this, I fancy, will depend a good deal upon the number of grazing animals in the neighbourhood, while their influence is regulated by the nature of the soil. Thus some pure *Sphagnum* formations are too boggy for sheep, which, however, can walk with safety on the soil of any of the other formations Many places are quite inaccessible to cattle, and still more so to horses.

Before concluding this section I must again emphasize the fact that, in considering the changes which have taken place in the vegetation of any region since the advent of man, it is conjointly and not separately that the influence of exotic plants, introduced animals, and fire must be considered.

HISTORY OF THE VEGETATION OF THE CHATHAM ISLANDS.

I do not intend to discuss at any length the history of the vegetation of the Chatham Islands, and the affinities between its species and those of other parts of the New Zealand area. A comparison of the species common to New Zealand and the Chatham Islands, detailing exactly any differences, however

slight, which distinguish the forms of the Chathams from those of New Zealand, would be a matter of high biological interest, but one which is hardly possible in the present state of knowledge regarding the plants. Judging by previous experience, species of the Chathams supposed to be endemic may be eventually shown to exist in other parts of the New Zealand biological area* when its botany is more fully investigated; while unrecorded species of local distribution may very possibly be discovered in the Chatham group. So far as genera are concerned, the Chatham Islands possess only one endemic genus, *Myosotidium.* Taking next the species of Buchanan's list (3), omitting a few the occurrence of which appears doubtful and adding others recorded here and elsewhere (37, 39, 40, 41) since its publication, there are about 166 species and distinct varieties of flowering-plants and fifty-one of vascular cryptogams in the Chatham Islands, giving a total of 217,† of which about thirty-one—*i.e.*, 14 per cent.—are considered by me to be endemic, while one, *Leucopogon (Styphylea) richei*, is, according to Baron Von Mueller, identical with an Australian species. All the remainder occur in some part or other of the New Zealand region; indeed, with the exception of *Rhopalostylis baueri(?)*, *Myrsine chathamica*, and *Pratia arenaria*, they are all to be met with in New Zealand proper. But many of the endemic species are so very closely related to New Zealand forms that it will always be a matter of opinion whether such are at best varieties, and not species at all.

From the above it may be seen clearly that there is little difference so far as species are concerned between the Chatham Islands and New Zealand, and, if the differences between related plants be taken as a measure of the length of time since they deviated from a parent stock, it seems right to consider the flora of the Chathams as a recent offset from that of New Zealand.

As to how the New Zealand plants made their way to the Chathams in the first instance geology teaches us that New Zealand at one time extended very much further to the east than at present, and that it is not unlikely that there was actual land-connection between the two groups of islands (33, p. 177), or if not land, then merely a narrow piece of sea across which the plants could easily migrate by means of birds, wind, and the other agencies discussed by Hemsley (28). Even if the ocean barrier had always been as wide as at present it seems quite possible that plants could find their

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* *Lepyrodia traversii*, *Hymenanthera chathamica*, and *Myrsine chathamica* were formerly considered endemic. The latter was collected by Mr. G. M. Thomson at the head of Wilson Bay, Stewart Island (50A).

† Drude gives only sixty-two indigenous phanerogams (17).

way from New Zealand to the Chathams without much difficulty. The sparrow and the blackbird, both now a nuisance on Chatham Island, reached that land, as pointed out before, unaided by man; the smoke of bush-fires from the North Island of New Zealand at times fills the air of Chatham Island when the wind blows from the north-east; finally, logs have again and again been cast up on all the sea-beaches. Old logs of *Podocarpus totara* are to be found in considerable numbers in the vicinity of the north coast buried under sand and in the beds of creeks, while in some places they occur at some distance inland, although there is no reason to think that such trees grew on the island.

But I do not think we need postulate any carriage over a broad tract of ocean for the Chatham Island plants; on the contrary, the geological evidence in favour of a wide extension of New Zealand eastwards is very strong, while zoological* and botanical support is not wanting. With regard to this latter, I am not in a position to make any further additions, either confirmatory or the contrary, to my recently published statements (10) regarding the difference in the life-history of certain so-called species according as they are indigenous to New Zealand or the Chatham Islands, so I reserve dealing with this part of my subject until such time as a number of seedling plants now under control are sufficiently developed for me to speak in a definite and exact manner as to their behaviour. All that can be said now on this head is that an examination of the conditions of life on Chatham Island has convinced me that local edaphic influences have played a greater part in modifying the vegetation than I had supposed, and that in consequence, although some of the plants of the Chatham Islands may much resemble certain Pliocene plants of New Zealand, the flora as a whole is not identically what it was in the Pliocene period, for some species must have deviated very considerably from the original type.

One of the difficulties that suggests itself in the way of accepting actual land-connection between New Zealand and the Chathams, and which supports the view that the breadth of ocean between the two lands must always have been wide, is the absence in the Chatham Islands of so many characteristic New Zealand genera; for it seems inconceivable, for example, that so common a New Zealand plant as *Cordyline australis*, or that so few of the other New Zealand species having fruits readily carried by birds, should not have reached the Chathams, even if there had

* One of the strongest zoological proofs is the migration from Chatham Island of the New Zealand shining cuckoo, a New Zealand migratory bird. As to the significance of this, see Captain Hutton's paper, "Our Migratory Birds" (33^3).

been a narrow piece of water to cross. If, however, a large area containing an abundant plant population becomes by degrees much restricted the struggle for existence must become much keener, and only those plants can survive, as certain stations become of very limited area, which can drive their competitors out of such stations; or, if themselves forced to move elsewhere, possess powers of rapid adaptation to the new conditions; or, what is often more important, some structure designed primarily for another purpose may, being put to a secondary use, enable them to hold their own in another station. Under the above circumstances many plants must be eradicated altogether, and others must take refuge in the most inhospitable places, while others, again, may easily occupy a quite different station from that to which they are accustomed. According to this view, the species of plants in the Chatham Islands must have decreased enormously in numbers since the time when the Chathams formed part of Greater New Zealand.*

How a very slight change in edaphic and climatic conditions can affect the vegetation of Chatham Island is exhibited by the two distinct regions of vegetation, the tableland and the lowland, each of which contains plants unknown or very scarce in the other. With quite a small modification of the above conditions numbers of plants would perish.

Several plants are extremely local; for instance, *Gunnera monoica* has been found in only one place in Chatham Island (11), although the ground in many places would seem to be an ideal station for it. There seems no reason why there should be only a very few trees of *Coprosma robusta* on the island when *C. chathamica* is one of the commonest trees. *Discaria toumatou*, found now in one or two places, should surely have become established on the fixed sand-dunes; but these, being suitable for forest growth, would not allow it to occupy what is a characteristic habitat in New Zealand. Other trees or shrubs of very limited distribution are *Dodonæa viscosa*, *Myoporum lætum*, *Leptospermum scoparium*, and *Plagianthus divaricatus*. Make the tableland a little wetter and *Olearia chathamica* would become simply a rock plant, and with the weathering of the rock on which it grew might be eradicated. Reduce the level of the island a few metres and *Sophora* would exist no longer. Bearing facts such as the above in

* For a different view of the case, see Mr. Cheeseman's paper on the "Flora of the Kermadec Islands" (6). The occurrence on Chatham Island of *Coprosma chathamica*, so closely related to *C. petiolata* of the Kermadecs, and of *Rhopalostylis baueri* in both regions, if the identification of the latter be correct, suggests that they travelled along the coast, which would, in the event of an east and north-east extension of New Zealand, join the Kermadecs and the Chathams.

mind, it is not unreasonable to suppose that Chatham Island contained at one time many more species than is now the case, and that even such a ubiquitous tree as *Cordyline australis* may have been there and been destroyed in the struggle for existence caused by the shrinking of the land.

NEW SPECIES OR VARIETIES MENTIONED IN THIS PAPER, WITH NOTES OR DESCRIPTIONS.

The material at my disposal is in nearly every case quite insufficient to enable me to draw up satisfactory diagnoses, so for the present it must suffice to point out what seem to be differences between the species considered to be new and those to which they are most closely allied. In some cases differences in the seedling form are used as a specific character, and such seem, indeed, to me to be among the very best characters that can be presented, showing a distinction between species which is constant, and not one which depends so much on environment as the leaf-form of the adult, or at times even the flower.

1. *Coprosma chathamica*, sp. nov.

A low tree attaining a maximum height of 15 m., never a trailing shrub. Extremities of ultimate branchlets pubescent with short greyish-white hairs; bark brown, wrinkled and glabrous below.

Leaves oblong, obovate, obovate-oblong, or sometimes lanceolate, tapering gradually into the short petiole, often about 4·9 cm. long by 2·3 cm. broad; glabrous except for pubescence on short petiole, and a few scattered hairs on midrib and margins; upper surface dark-green and shining; undersurface very pale, strongly marked by reticulations of veins.

Female flowers: Calyx-limb truncate; corolla deeply divided into four lobes; lobes 3·5 mm. to 4 mm. long; drupe large, ovoid, 1·2 cm. long by 9 mm. through its thickest portion.

Seedling: Cotyledons large, 3 cm. by 1·8 cm., or larger or smaller, obovate, obtuse, glabrous except on short petiole; early seedling leaves larger than the cotyledons, oblong, acute, thin, densely ciliated and hairy on petioles and midrib, with hairs scattered also over surface of lamina; lamina 3·4 cm. by 1·9 cm. to 2·25 cm. by 1·2 cm., or larger or smaller. Stem and upper part of hypocotyl pilose, with hairs similar to those of leaf; hairs white, but sometimes red.

This species is *C. baueriana* of Buchanan's list. It is referred to *C. petiolata*, Hook. f., by Mr. T. Kirk (37, p. 232). Mr. T. F. Cheeseman has kindly sent me specimens of the latter species, collected by himself in the Kermadec Islands, for comparison. These have shorter pubescence than *C.*

chathamica, giving a grey colour to the twigs; the corolla lobes are very short, and the stigmatic hairs are much shorter than in *C. chathamica*. *C. chathamica* is also always a tree, and never a shrub, as is the case with *C. petiolata*. Seedlings of *Coprosma petiolata* are much wanted.

2. *Dracophyllum arboreum*, sp. nov.

Always a low tree, never a shrub. Passes in course of development through a broad-leaved juvenile form, which persists until plant is 3·5 m. tall, when the adult shorter needle-shaped leaves make their appearance. Adult trees usually have some shoots bearing only juvenile leaves. Juvenile leaves 20 cm. long by 1·5 cm. broad, gradually tapering from base to a fine point. Adult leaves needle-shaped, 7·5 cm. long by 2 mm. broad. Both forms of leaves tomentose on margin. Flowers very similar to those of *D. scoparium*. See coloured plate in "Flora Antarctica" (30).

If *Dracophyllum scoparium*, to which this plant was referred by both Hooker and Buchanan, does not go through the same remarkable changes, I cannot see that they can possibly be the same species, notwithstanding similarity of flowers.

3. *Dracophyllum paludosum*, sp. nov.

After a good deal of hesitation I decided to give a name to this species, for it was necessary to have some name to distinguish this plant from *D. arboreum*. From the latter species it differs in its shrubby habit, and especially in its never passing through an extended juvenile stage with broad leaves. Its racemes are rather shorter than those of *D. arboreum*, and its flowers rather smaller. Perhaps this plant may prove identical with *D. scoparium* or with some of the forms of *D. urvilleanum*.

4. *Myrsine coxii*, sp. nov.

A shrub with ultimate branchlets pubescent and leaves forming rather a dense mass, reaching a maximum height of about 4 m., but often very much lower.

Leaves narrow-obovate, tapering gradually at base into a short petiole, averaging about 2·4 cm. by 9 mm.

Flowers in fascicles of three or more, rarely in pairs, crowded together on the naked portions of the ultimate branches, occasionally 1-flowered in the axils of the upper leaves; almost sessile, but pedicels lengthening a little in fruit.

Calyx 4-fid to slightly below middle; segments ovate, with broad base, pale-green, ciliated, marked with a few red glandular dots, acute.

Petals 4, narrow obovate-oblong, 3·25 mm. by 2 mm., pale yellowish-green with margin stained pale-purple, much more purple in bud, ciliated, marked towards apex with several glandular red dots, obtuse.

Fruit globose, bright mauve-coloured, 5 mm. long, by 6 mm. broad.

This plant is probably the *Myrsine nummularia* of Buchanan's list, to which it bears no resemblance whatsoever. It differs from *M. chathamica* in several points, the latter plant being a small tree with a thick trunk, with leaves larger and proportionately broader than *M. coxii*, and having flowers in fascicles of more than three, with distinct pedicels. It also comes into bloom a month later than *M. coxii*. It gives me great pleasure to call this species after my friend Mr. F. A. D. Cox.

5. *Veronica gigantea*, sp. nov.

This is *V. salicifolia* of Buchanan's list. It differs from *V. salicifolia* in being always a low tree with a distinct trunk. Its seedling form also is quite distinct from that of any form of *V. salicifolia* examined by me. The early leaves are very coarsely and deeply toothed, and their margins are evenly and closely ciliated with hooked white hairs. The stem is extremely pubescent, and even the hypocotyl is quite downy. Later juvenile leaves are larger than the adult leaves, lanceolate, sessile, entire, acute, ciliated, and with still longer hairs on the prominent midrib, and such are found on a plant 32 cm. tall or even much taller. The stem is usually purple, rather soft, and covered with many long soft hairs pressed to its surface. My notes say, "The intense hairiness of this plant even at this stage is very remarkable." The juvenile plant much resembles *V. pubescens* of New Zealand, for a specimen of which rare plant I am indebted to Mr. Cheeseman, but the inflorescence brings it closer to *V. salicifolia*. The adult leaves are narrow-lanceolate, quite sessile, 8·3 cm. long by 1·8 cm. broad, minutely ciliated, and with the midrib not nearly so much keeled as in *V. salicifolia*.

6. *Plagianthus chathamicus*, sp. nov.

I have separated this plant from *P. betulinus* because they differ in the seedling state, and *P. chathamicus* is also never furnished with reversion shoots. I have gone at some length into this matter elsewhere, and have, as before stated, nothing further to add at present (10).

7. *Sophora chathamica*, sp. nov.

Exactly the same remarks apply to this species as those made above with regard to *Plagianthus chathamicus*. I have

already published a note as to its seedling form (9, p. 373), and shown it to be probably distinct from that of any other hitherto described New Zealand species of *Sophora*.

8. *Geranium traversii*, Hook. f., var. *elegans*, var. nov.

Petals pink, veined on upper surface with fine lines of darker pink. The typical *G. traversii* has white flowers.

9. *Linum monogynum*, Forst., var. *chathamicum*, var. nov.

Petals broadly striped or flaked with pale blue. The type has white flowers.

10. *Olearia chathamica* var. *dendyi*, var. nov.

Tomentum (when dry) yellower and denser than that of the type. Florets purple. The type has white florets, which, when fading, are of a purplish colour.

Hab. Pitt Island. Collected by Professor A. Dendy, after whom I have much pleasure in naming this variety.

11. *Agropyrum coxii*, Petrie, sp. nov.

A description of this very distinct grass by Mr. Petrie is, I understand, to appear in the same volume of the Transactions as this paper.

12. *Poa chathamica*, Petrie, sp. nov.

Mr. Petrie considers this grass closely related to *P. anceps*. A description is included in the same paper as that containing *Agropyrum coxii*.

Plants collected during the Author's Visit which had not been previously recorded for the Chathams.

Acæna novæ-zelandiæ, T. Kirk.
Cladium gunnii, Hook. f.
Epilobium cæspitosum, Hausskn.
" *pedunculare*, A. Cunn.
" *insulare*, A. Cunn.
" *chionanthum*, Hausskn., var., perhaps var. nov.
" *novæ-zelandiæ*, Hausskn(?).
Galium tenuicaule, A. Cunn.
Gunnera monoica, Raoul.
Hydrocotyle robusta, T. Kirk. This may be a new species, and not *H. robusta*.
Limosella aquatica, L., var. *tenuifolia*.
Myosotis spathulata, Forst. So named in Kirk's handwriting in the herbarium of Christchurch Museum.

There are probably also one or two undescribed species of *Veronicas* amongst my collection.

SPECIES RECORDED IN BUCHANAN'S LIST THE OCCURRENCE OF WHICH SEEMS VERY DOUBTFUL.

Epilobium confertifolium, Hook. f., var. *a*.

Aciphylla lyallii, Hook. f., and *Aciphylla monroi*, Hook. f. These two are most likely forms of *A. traversii*.

Coprosma baueriana, Endl. = *Coprosma chathamica*, sp. nov.

Brachycome sinclairii, Hook. f. = perhaps *Lagenophora forsteri*.

Pratia macrodon, Hook. f. = *Pratia arenaria*, Hook. f.

Dracophyllum rosmarinifolium, Hook. f. = depauperated forms of *D. paludosum*, sp. nov.

Gentiana pleurogynoides, Griesb. = G. *pleurogynoides* var. *umbellata*, Kirk, which is probably a distinct species, as suggested to me as possible by both Mr. Petrie and Mr. Cheeseman.

Veronica salicifolia, Forst. = *V. gigantea*, sp. nov.

Myrsine nummularia, Hook. f. = *M. coxii*, sp. nov.

Areca sapida, Sol. = *Rhopalostylis baueri*, Wendl. and Drude(?). Whatever species the Chatham Island palm may be, it is not *R. sapida*, for it differs altogether from that species in the seedling form.

Astelia cunninghamii, Hook. f.

Poa foliosa, Hook. f., var. *a*.

Trisetum subspicatum, Beauv.

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EXPLANATION OF PLATES XVI.–XIX.*

PLATE XVI.

Cotula featherstonii growing under cliffs at Matarakau. In foreground is *Mesembryanthemum australe*.

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* Reproduced from original photographs by the author.

PLATE XVII.

Myosotidium nobile, growing in same locality as *Cotula*, in Plate XVI.

PLATE XVIII.

Isolated plant of *Olearia semidentata*, with formation of *Dracophyllum paludosum* in background. Tableland south of Chatham Island.

PLATE XIX.

Portion of formation shown in Plate XVIII., with juvenile plant of *Dracophyllum arboreum* in foreground still in the broad-leaved stage. In background is *Dracophyllum paludosum*.

ART. XXIX.—*On a New Zealand* Isotachis *new to Science*.

By ERNEST S. SALMON.

Communicated by Robert Brown.

[*Read before the Philosophical Institute of Canterbury, 6th November, 1901.*]

Plate XX.

THE following description of a New Zealand *Isotachis* by Mr. E. S. Salmon, of Charlton House, Kew, was taken from specimens which I sent to him for determination. His description (which I am able to confirm) was published in the *Revue Bryologique* for June, 1901, at page 75. He has sent me copies of his paper, with drawings, one of which, with specimens of the plant, has been placed in the Museum at Christchurch.

Isotachis stephanii, sp. nov.

Robusta, dense cæspitosa, flaccida, sordide badia; caule usque ad 8 cent. longo flexuoso supra in ramulos subjulaceos partito interdum simplici inferne sordide badio apice læte badio, foliis distichis dense imbricatis flaccidis tenuibus erectis vel erecto-patentibus amplexicaulibus subcomplicatis late oblongis 3–3·5 mm. longis 2·5–3 mm. latis basi ventricosis margine integro vel obtuse dentato ad 1/7 bifidis sinu infra plus minus angustato segmentis late triangularibus plerumque minute apiculatis cellulis superioribus firmis quadratis et breviter rectangulis 30–50 μ longis 12–20 μ latis parietibus plus minus incrassatis trigonis nullis, cellulis inferioribus elongato-rectangulis, amphigastriis foliis paulo minoribus 2·5–3 mm. longis 2 mm. latis parum concavis cæteris conformibus.

Reliqua ignota.

I. grandi Carr. et Pears. affinis, sed habitu robustiore, foliis et amphigastriis majoribus minus profunde bifidis distincta.

Hab. Growing in water in large round tufts on the top of a hill at Orepuki, Foveaux Strait; on the summit of Mount Thompson, one of the spurs of Mount Anglem, Stewart Island, New Zealand (Robert Brown, *in litt.*, January, 1901).

The hepatic above described was sent to me by Mr. Robert Brown, of New Zealand. The specimens sent, although sterile, clearly belonged to *Isotachis*, a genus which, as Gottsche has remarked (see Carrington and Pearson, in Proc. Linn. Soc. N.S.W., sec. ser., ii., p. 1042, 1888), "is readily recognised by its evenly arranged leaves and stipules, which last so nearly resemble the leaves in size and form that the foliage might almost be called trifarious." Not being able to identify the plant with any species of *Isotachis* in the Kew Herbarium, I sent a specimen to Herr Stephani, who kindly informed me that it was a new species. I am indebted to Herr Stephani for the following note on the affinity of the present plant: "It is very near *I. grandis*, Carr. et Pears., but that plant has asymmetric leaves, the postical part being more rounded than the antical. It is a particular feature of the New Zealand plant that the leaves and stipules are perfectly symmetric. *I. grandis* also has the leaves (not always, but often) 3-lobate."

There is a small specimen of *I. grandis* ("on wet rocks, Lawson, Blue Mountains, N.S.W.") in the Kew Herb., and in this the largest leaves measure 2 mm. by 1·75 mm. (Carrington and Pearson give 1·75 mm. by 1·5 mm.); the stipules measure 1·5 mm. by 1 mm. *I. stephanii*, besides having much larger leaves and stipules, differs in the manner in which the apex of these is bipartite. This is seen most clearly in the case of the stipules—in *I. grandis* the stipule is concave at the base of the sinus, and the sinus is not narrowed towards the base; in *I. stephanii* the apex of the stipule is plane, and the shallow sinus is distinctly narrowed downwards.

EXPLANATION OF PLATE XX.

Isotachis stephanii, sp. nov.

Fig. 1. Part of plant, about natural size (left-hand branch turned round to show the stipules).
Fig. 2. Leaf (flattened); × 17.
Fig. 3. Stipule; × 17.
Fig. 4. Areolation of leaf towards apex; × 270.
Fig. 5. Areolation of leaf towards base; × 270.
Fig. 6. Transverse section of stem; × 170.

Isotachis grandis, Carr. et Pears.

Fig. 7. Leaf (flattened); × 17.
Fig. 8. Stipule; × 17.

Additional notes on the habitats of this plant: It grows on the nearly flat portions of the summits of the hills already named, in the drainage, which flows very slowly, varies in width from 1 ft. to several feet, and is about 1 in. in depth, with a muddy bottom. It is a very beautiful plant, being lustrous and nearly black. Like a large number of New Zealand plants, it appears to be very local. It is not plentiful in the localities named, which up to the present are the only places where it has been found. Fruit not known. —R. B.

ART. XXX.—*Revised List of New Zealand Seaweeds: Part II.**

By ROBERT M. LAING, B.Sc.

[*Read before the Philosophical Institute of Canterbury, 6th November, 1901.*]

HERE, as in the previous part of this paper, no attempt is made to give a complete synonymy of the species. Only such references are given as will introduce the student to the chief literature of the subject, where he will find full descriptions, and also fuller lists of synonyms, which will enable him to pursue his investigations. I have to express my thanks to Major Reinbold for his kindness in identifying a number of specimens.

Sub-class FLORIDEÆ.

Order **Ceramiaceæ.**

96. *Rhodocorton parkeri*, Harvey Gibson, Journ. of Bot., 1893, p. 161.

Brighton, Otago: *Professor Parker.*

This plant was apparently found epiphytic on *Lychæte darwinii* (*vide* Laing, Trans. N.Z. Inst., vol. xxvii., p. 300).

97. *Rhodocorton (Callithamnion) rothii.* Fl. Nov.-Zel., p. 260.

Hawke's Bay and Cape Kidnappers: *Colenso.*

This plant has not been collected lately, but might be overlooked on account of its smallness.

* For Part I., see Trans. N.Z. Inst., vol. xxxii., art. xiv.

98. *Antithamnion ptilota,* Harvey Gibson, Journ. of Bot., 1893, p. 161 (*Callithamnion ptilota,* Hook. and Harv., Lond. Journ. Bot., iv., p. 272).

New Zealand: *Professor Parker.*

99. *Antithamnion (Callithamnion) adnatum,* J. Ag., De Alg. N.Z. mar., p. 12.

Bay of Islands, on *Gelidum corneum: Berggren.* Lyall Bay: *R. M. L.*

Specimens found by Major Reinbold amongst seaweeds sent Home by myself from Lyall's Bay seem to belong to this species. It is, however, by no means a well-known plant.

100. *Antithamnion (? Callithamnion) applicitum.* Fl. Nov.-Zel., p. 258.

Parasitical on *Amphiroa: Colenso.*

A little-known and not recently collected species.

101. *Antithamnion (Callithamnion) plumula.* Fl. Nov.-Zel., p. 258.

D'Urville Island: *Lyall.*

Var. *investiens.* St. Clair: *J. C. S.* (Conf. J. Ag.).

102. *Callithamnion flaccidum.* Fl. Nov.-Zel., p. 258.

Otago: *Lyall.*

I have some plants from the west head, Wellington, which come close to this; but in the absence of type specimens it is practically impossible to identify them with certainty.

103. *Callithamnion puniceum.* Fl. Nov.-Zel., p. 259.

Tauranga: *Davies.*

I know nothing about this plant. It appears among Agardh's "Species inquirendæ."

104. *Callithamnion consanguineum.* Fl. Nov.-Zel., p. 260.

Port Nicholson: *Lyall.* Bluff: *J. C. S.*

I know nothing about this plant. This plant also appears among Agardh's "Species inquirendæ."

105. *Callithamnion byssoideum.* Fl. Nov.-Zel., p. 260.

Bluff and Otago: *Lyall.* Maketu: *Chapman.*

106. *Callithamnion brachygonum.* Fl. Nov.-Zel., p. 259.

Blind Bay: *Lyall.* Tauranga: *Davies.* Dunedin Wharf: *J. C. S.* and *R. M. L.* Warrington: *Berggren.* Wellington Harbour: *R. M. L.*

107. *Callithamnion hirtum.* Fl. Nov.-Zel., p. 258.

Port Cooper, Otago, Port Underwood, Port William, Tory Channel: *Lyall.*

This is probably the commonest of our species of *Callithamnion.* It is everywhere plentiful in the South Island.

108. *Callithamnion colensoi.* Fl. Nov.-Zel., p. 259.
East Coast and Hawke's Bay: *Colenso.*

109. *Callithamnion mucronatum,* J. Ag., Sp., p. 29.
Dunedin: *R. M. L.; J. C. S.*

110. *Callithamnion(?) confusum,* Harv. J. Ag., Epicr., p. 250. (*Wrangelia squarrulosa:* Fl. Nov.-Zel., p. 236.)
New Zealand: *Lyall.*

111. (??) *Warrenia comosa,* Harv. (*Callithamnion comosum,* J. Ag., Epicr., p. 19.)
The Nuggets, Wyckliffe Bay, St. Clair: *R. M. L.* St. Clair: *J. C. S.*
A beautiful plant; the identification due to Agardh, but to me it seems very doubtful.

112. *Pleonosporium brounianum,* Harv. (Harvey Gibson, Journ. of Bot., 1893, p. 161.)
Brighton(?): *Professor Parker.*

113. *Ballia callitricha.* Fl. Nov.-Zel., p. 257. (*Vide* "On the Minute Structure of *Ballia callitricha,*" Archer, Lin. Soc. Trans., Dec., 1876.)
Chatham Islands: *Dr. Schauinsland.* Bluff, Dunedin, Warrington, Banks Peninsula: *Berggren.* Common along the east coast of the South Island; Lyall Bay: *R. M. L.* Dredged in 8 fathoms at Akaroa: *H. Suter!*

114. *Ballia scoparia,* Harv. (*Callithamnion scoparium:* Fl. Nov.-Zel., p. 259.)
Common along the east coast of the South Island.

115. *Griffithsia sonderiana,* J. Ag., Epicr. Flor., p. 62.
This is probably the common species of *Griffithsia,* but the New Zealand forms are not sufficiently known.

116. *Griffithsia antarctica.* Fl. Nov.-Zel., p. 258.
East Coast: *Colenso.* Ruapuke, Foveaux Strait, and East Coast: *Lyall.*
I have not yet been able to recognise this species with certainty among my specimens.

117. *Pandorea traversii,* J. Ag., in Enum. Alg. Chatham.
Chatham Islands: *Travers.* Lyall Bay: *Berggren.* Paterson's Inlet; also abundant for some months in Sumner, at Taylor's Mistake, and on the coast near Wellington: *R. M. L.*

118. *Ptilota pellucida.* Fl. Nov.-Zel., p. 257.
Otago: *Lyall.* Dunedin, Warrington, Banks Peninsula: *Berggren.* The Nuggets, Lyall Bay: *R. M. L.* St. Clair: *J. C. S.*
Mr. Smith informs me that this plant was by no means uncommon in the neighbourhood of St. Clair some four or five

years ago, but that it seems to have disappeared completely since then. My Wellington specimens (1901) are epiphytic on *P. formosissima.*

119. *Ptilota formosissima.* Fl. Nov.-Zel., p. 257.

Probably everywhere abundant. Bluff, Dunedin, Warrington(?), Banks Peninsula, Lyall Bay: *Berggren.* Kaikoura: *R. M. L.* Chatham Islands: *Dr. Schauinsland.* Brighton (Otago): *J. C. S.*

120. *Ceramium virgatum,* Harv., Fl. Nov.-Zel., p. 256.

East Coast: *Colenso.* Taylor's Mistake: *R. M. L.* Chatham Islands (identification doubtful): *Dr. Schauinsland.*

(*Vide* also Anal. Algol., cont. ii., p. 44.)

121. *Ceramium diaphanum.* Fl. Nov.-Zel., p. 256.

Port Cooper, Akaroa, and Otago: *Lyall.* Petone: *R. M. L.* St. Clair (common): *J. C. S.*

122. *Ceramium nodiferum,* J. Ag., Epicr., p. 99.

Chatham Islands: *Travers.* New Zealand: *(Agardh).*

(*Vide* also Anal. Algol., cont. ii., p. 40.)

123. *Ceramium stichidiosum,* J. Ag., Epicr., p. 105. (Anal. Algol., cont. ii., p. 21.)

Cape Kidnappers: *A. Hamilton!* Chatham Islands: *Dr. Schauinsland.* Var., Lower Green Island beach: *R. M. L.*

124. *Ceramium vestitum.* Fl. Nov.-Zel., p. 256. (J. Ag., Anal. Algol., cont. ii., p. 40).

Port Adventure: *Lyall.* Dunedin, Banks Peninsula: *Berggren.*

This is a little-known and somewhat doubtful species.

125. (?) *Ceramium pusillum* var. *lanceolatum,* Harv., in Syn. Phyc. Austr., No. 619. (J. Ag., Alg. N.Z. mar., p. 14; also Anal. Algol., cont. ii., p. 21.)

Tauranga: *Berggren.*

126. *Ceramium uncinatum.* Fl. Nov.-Zel., p. 257. (J. Ag., Anal. Algol., cont. ii., p. 36.)

Turnagain: *Colenso.* Lyttelton, Lyall Bay, Whangaroa: *R. M. L.*

This is a very distinct species, and probably common all along the coast. The tetraspores do not seem to have been previously described. They are of the usual type, and are arranged in a single verticillate series round the nodes. Originally totally immersed, when mature they emerge almost completely vertically, and are surrounded by a conspicuous hyaline membrane. It therefore belongs to the tribe *Isogonia* rather than to *Zygogonia,* in which Agardh provisionally placed it. The arrangement of the spines has been also imperfectly described by Harvey and Agardh. There are gene-

rally five at each node, a large one on the anterior side of the ramulus, two smaller ones on the posterior side. The remaining two are still smaller, and are intermediate in position on either side between the large one and the two smaller ones. They are difficult to distinguish until the specimen has been decolourized.

127. *Ceramium apiculatum*, J. Ag., Epicr., p. 105. (*C. cancellatum:* Fl. Nov.-Zel., p. 265.) (*Vide* also Anal. Algol., cont. ii., p. 20.)

On various parts of the coast (common): *Lyall; Colenso; Davies; Chapman.* Lyall Bay and Tauranga: *Berggren.*

128. *Ceramium rubrum.* Fl. Nov.-Zel., p. 256.

Brighton (Otago), Lyttelton(?): *R. M. L.* Bluff, Owaka Beach, Green Island, St. Clair: *J. C. S.*

According to Harvey many varieties of this plant are abundant throughout the Islands. It does not seem to me that this is the case, and so I give a list of the localities at which I have obtained apparently authentic specimens of it. Further examination will probably show that the name has been used as a cover for several species.

129. *Ceramium divergens*, J. Ag., Anal. Algol., cont. ii., p. 27.

New Zealand: (*Agardh.* No locality given).

130. *Ceramium nobile*, J. Ag., Anal. Algol., cont. ii., p. 41.

Brighton (Otago): *R. M. L.* St. Clair: *J. C. S.*

131. *Ceramium gracillimum*, Harv., Phyc. Brit., tab. 206. (J. Ag., Epicr., p. 95; also Anal. Algol., cont. ii., p. 43.)

Major Reinbold has kindly identified this plant for me from specimens forwarded to him and collected by myself at Lyall's Bay and in the neighbourhood of Wellington (Petone). The species is perhaps the same as *C. byssoideum* (Harv., Ner. Bor. Amer., ii., p. 218).

132. *Ceramium miniatum(?)*, (Suhr) J. Ag., Epicr., p. 105.

To this species Agardh somewhat doubtfully refers specimens collected by myself and Mr. Crosby Smith in Otago Harbour.

133. *Microcladia pinnata*, J. Ag., Anal. Algol., cont. iv., p. 34.

Brighton (Otago): *J. C. S.; R. M. L.*

134. *Microcladia novæ-zelandiæ*, J. Ag., Anal. Algol., cont. iv., p. 35.

This is almost certainly *M. coulteri* of Professor Harvey Gibson (Journ. of Bot., 1893, p. 161). It is very common from Lyttelton southwards, and it is strange that it has not been noted by any of the earlier collectors. This species

varies a good deal, and perhaps runs into the preceding; but there also appears to be a third form yet unnamed. The two species were named by Professor Agardh from specimens sent Home by Mr. Crosby Smith and myself. But in the interchange of letters some mistake has arisen about the labels, and I am now unable to lay my hands on type specimens of *M. pinnata*.

135. *Centroceras clavulatum*. Fl. Nov.-Zel., p. 277.
Common on the coast and in river-estuaries: *R. M. L.*

Order **Cryptonemiaceæ.**

136. *Schizymenia stipitata*, J. Ag., Epicr., p. 121.
Banks Peninsula (very sparingly): *Berggren.*

137. *Schizymenia novæ-zelandiæ*, J. Ag., Epicr., p. 677 (also Anal. Algol., cont. v., p. 76).
Bay of Islands: *Berggren.*

138. *Nemastoma intestinalis*. Fl. Nov.-Zel., p. 255.
Preservation Harbour: *Lyall.* Chatham Islands: *Dr. Schauinsland.*

139. *Nemastoma laciniata*, J. Ag., Epicr., p. 128. (*Vide* Note, Anal. Algol., cont. v., p. 76.)
Dunedin and Banks Peninsula (very sparingly): *Berggren.* I have a specimen (from Lyall Bay, I think), but I have unfortunately lost the name of the locality.

140. *Pachymenia lusoria*, J. Ag., Epicr., p. 145. (*Iridea lusoria*: Fl. Nov.-Zel., p. 252.)
Apparently abundant from Mongonui to Stewart Island. I may have occasionally mistaken some other plant for it, for its identification is often impossible without a very close examination; but it appears to be one of the commonest of our red seaweeds on exposed tidal rocks.

141. *Pachymenia dichotoma*, J. Ag., Epicr., p. 146.
Bluff: *Berggren*, *R. M. L.*

142. *Pachymenia himantophora*, J. Ag., Epicr., p. 680.
Bay of Islands: *Berggren.* Stewart Island: *R. M. L.* Identification somewhat doubtful.

143. *Pachymenia laciniata*, J. Ag., Epicr., p. 145.
Bluff, Dunedin (sparingly): *Berggren.*

144. *Æodes nitidissima*, J. Ag., Epicr., p. 630.
Bay of Islands: *Berggren.* Mongonui: *R. M. L.*
There is a specimen in the Canterbury Museum, from Tauranga.

145. *Grateloupia prolifera*, J. Ag., Epicr., p. 150. (? *Nemastoma prolifera*, Harv., in Fl. Nov.-Zel., ii., p. 255.)
Chatham Islands: *Travers.* Lower Green Island beach, Wyckliffe Bay, and Lyttelton: *R. M. L.*

146. *Grateloupia (Aræotes) stipitata*, J. Ag., Epicr., p. 151. (? *Nemastoma attenuata*, Harv., Fl. Nov.-Zel., p. 255.)
Dunedin: *Berggren.* Lower Green Island beach and Lyall Bay: *R. M. L.*

147. *Grateloupia (Gloiogenia) pinnata*, J. Ag., Epicr., p. 151. (*Nemastoma pinnata*, Harv., Fl. Nov.-Zel., ii., p. 255.)
Akaroa, Tauranga, Port Underwood, Blind Bay(?), Port Nicholson: *Lyall* and *Davies.* Tauranga and Lyall Bay: *Berggren.* Gore Bay, Wellington Harbour, Lyttelton: *R. M. L.*

148. *Grateloupia filicina*, J. Ag., Epicr., p. 153.
Chatham Islands: *Dr. Schauinsland.*

149. *Cryptonemia latissima*, J. Ag., Epicr., p. 682.
Bay of Islands: *Berggren.*

Order **Gigartinaceæ.**

I have a large number of species belonging to this order, but so far have been able to identify a few of them only. It presents unusual difficulties.

150. *Rhodoglossum latissimum*, J. Ag., Epicr., p. 187. (Also Bidr. Alg. Syst., iii., p. 27; (?)*Halymenia latissima*, Harv., Fl. Ant.)
New Zealand: *Berggren.* Lyall Bay: *Reinbold* (amongst specimens sent Home by myself).

151. *Gigartina divaricata*, Hook., Crypt. Fl. Ant., p. 75. (J. Ag., Epicr., p. 195; Anal. Algol., cont. v., p. 10.) *G. pistillata*: Fl. Nov.-Zel. *(partim)*.
Bay of Islands: *Berggren.* Kekerangu: *R. M. L.*
Var. *gymnongongriodes*, J. Ag., *loc. cit.*
Bay of Islands: *Berggren.*

152. *Gigartina livida*, Turn., Hist. Fuc., vol. iv., pl. 254. (J. Ag., Anal. Algol., cont. v., p. 11.) *G. pinnata*, J. Ag., Sp. Alg., p. 270; Epicr., p. 196: Harv., Phyc. Austr., pl. 68.
Wyckliffe Bay: *R. M. L.*

153. *Gigartina flabellata*, J. Ag., Epicr., p. 194.
New Zealand: *Harvey Gibson* (Journ. of Bot., June, 1893). Lyall Bay: *R. M. L.*

154. *Gigartina clavifera*, J. Ag., Epicr., p. 194.
Bluff: *Berggren.* Akatore, Brighton, Lyall Bay: *R. M. L.*

155. *Gigartina laciniata*, J. Ag., Epicr., p. 197.
Chatham Islands: *(Agardh).*

156. *Gigartina protea*, J. Ag., Bidr. Alg. Syst., part iv., p. 29.
Western coast of New Zealand: *(Agardh).* Kekerangu, Lyttelton: *R. M. L.*

The identification of my Lyttelton specimens is due to Agardh, but is somewhat doubtful.

157. *Gigartina polyglotta*, J. Ag., Bidr. Alg. Syst., part iv., p. 29.

Western coast of New Zealand: *(Agardh)*.

158. *Gigartina alveata*. Fl. Nov.-Zel., p. 547. (J. Ag., Anal. Algol., cont. v., p. 20.)

New Zealand: *Banks; Cunningham; Hooker*. Bay of Islands: *Berggren*.

159. *Gigartina angulata*, J. Ag., Epicr., p. 197. (*Vide* also Anal. Algol., cont. v., p. 20.) (? *G. stiriata*, Harv., Fl. Nov.-Zel.)

Chatham Islands, Bluff: *Berggren*. Brighton (Otago), Double Corner (Amberley), Lyall Bay: *R. M. L.* Probably common in the South Island at least: *R. M. L.*

Professor Harvey Gibson also describes *G. stiriata* as from New Zealand (Journ. of Bot., June, 1893). I have seen one of his specimens, and am satisfied that it is *G. angulata*, J. Ag. The true *G. stiriata* is a native of Cape Colony.

160. *Gigartina chapmanni*. Fl. Nov.-Zel., p. 291, pl. 119. (J. Ag., Epicr., p. 190.)

Tauranga, Bay of Islands: *Berggren*(?). Petone (Wellington Harbour): *R. M. L.*

161. *Gigartina macrocarpa*, J. Ag., Epicr., p. 683. (*G. pistillata*: Fl. Nov.-Zel., ii., p. 252, *partim*.)

Bay of Islands: *Berggren*.

The old species *G. pistillata* has been split up into several by Agardh. It was said to be common on the New Zealand coast. It will probably be found that the common form is *G. divaricata*.

162. *Gigartina disticha*, J. Ag., Epicr., p. 194. (Anal. Algol., cont. v., p. 10.)

Dunedin: *Berggren*.

163. *Gigartina marginifera*, J. Ag., Epicr., pp. 196, 683.

Dunedin, Warrington, Banks Peninsula: *Berggren*.

164. *Gigartina decipiens*. Fl. Nov.-Zel., p. 547. (J. Ag., Epicr., p. 195; also Anal. Algol., cont. v., p. 20.)

Dunedin, Banks Peninsula: *Berggren*. Akatore, Lower Green Island, Double Corner (Amberley), Lyall Bay: *R. M. L.*

As most of my specimens are barren, it is possible that an allied species may sometimes have been mistaken for *G. decipiens*.

165. *Gigartina insidiosa*, J. Ag., Anal. Algol., cont. v., p. 22.

This plant is apparently from New Zealand, though no definite locality is given for it.

166. *Gigartina ancistroclada*, Montagne. J. Ag., Epicr., p. 198.

Akaroa: *D'Orville* Otago: *Lyall.*

167. *Gigartina burmanni*, J. Ag., Epicr., p. 204.

"Specimen vero (*i.e.*, *Gigartina burmanni*) me habuisse ex littore occidentali Novæ-Zelandiæ habui mihi a Ferd. de Mueller missum quod quonam modo a capensi specie dignosceretur, mihi quidem hodie non liquet." (J. Ag., Anal. Algol., cont. v., p. 27.)

168. *Gigartina lanceata*, J. Ag., Anal. Algol., cont. v., p. 29.

West coast of New Zealand: *Baron F. von Mueller.*

169. *Gigartina fissa*, Suhr. J. Ag., Epicr., p. 20. (*Iridea lanceolata*, Harv., Fl. Nov.-Zel., ii., p. 252.)

Auckland Islands: *Captain Fairchild.* New Zealand: *Baron F. von Mueller.* Otago: *Lyall.* Bluff: *Berggren.*

170. *Gigartina circumcincta*, J. Ag., Epicr., p. 202. (*Gigartina radula*, Harv., Fl. Nov.-Zel.)

Apparently a very common species from the Bluff northwards: *R. M L.*

171. *Gigartina atropurpurea.* Bidr. Alg. Syst., iv., p. 31. (*Iridea atropurpurea*, J. Ag., Epicr., p. 181.)

Bay of Islands(?): *Berggren.* Worser Bay: *R. M. L.*

172. *Gigartina apoda*, J. Ag., Anal. Algol., cont. v., p. 31.

New Zealand: *(Agardh).*

173. *Gigartina grandifida*, J. Ag., Epicr., p. 684.

Chatham Islands: *Travers*(?).

(*Vide* Bidr. Alg. Syst., iv., p. 30.)

174. *Gigartina rubens*, J. Ag., Bidr. Alg. Syst., iv., p. 30. (Anal. Algol., cont. iv., p. 34.)

New Zealand: *(Agardh).*

175. *Gigartina orbitosa*, J. Ag., Anal. Algol., cont. v., p. 36.

New Zealand: *(Agardh).*

I have specimens of one, or all of the last three species, but at present am quite unable to distinguish them satisfactorily, so I give no localities.

176. *Gigartina longifolia*, J. Ag., Anal. Algol., cont. v., p. 39.

New Zealand: *(Agardh).*

177. *Carpococcus linearis*, J. Ag., Epicr., p. 586. (Anal. Algol., cont. v., p. 43.)

Chatham Islands: *Travers.*

178. *Ahnfeltia torulosa*, J. Ag., Epicr., p. 208. (*Gymnogongrus furcellatus*, in part, Fl. Nov.-Zel., p. 250.)

Bay of Islands: *Berggren.*

179. *Ahnfeltia furcata*, J. Ag., Epicr., p. 208. (*Plocaria furcata*, Hook. and Harv., Lond. Journ., iv., p. 545(?). *Gymnogongrus furcellatus*, in part; Fl. Nov.-Zel., p. 250.)

New Zealand: *(Agardh).*

180. *Gymnogongrus nodiferus*, J. Ag., Epicr., p. 210. (*Gymnogongrus furcellatus*: Fl. Nov.-Zel., p. 250, in part.)

Bay of Islands: *Sinclair*. Bluff, Lyall Bay, Bay of Islands: *Berggren*. Dunedin, Kekerangu: *R. M. L.*

181. *Stenogramma interruptum*. Fl. Nov.-Zel., p. 249.

Blind Bay (Nelson), Cook Strait, and Chalky Bay (West Coast): *Lyall*. Bluff, Lyall Bay, Tauranga, Bay of Islands: *Berggren*. Lyall Bay: *R. M. L.* Riverton, Dunedin: *J. C. S.* Kidnappers: *Hamilton!*

182. *Dactylmenia berggreni*, J. Ag., Anal. Algol., cont. v., p. 51. (*Kallymenia berggrenni*, J. Ag., Epicr., p. 221. *K. harveyana*: Fl. Nov.-Zel., p. 251(?).)

Bluff and Lyall Bay (very sparingly), Bay of Islands (plentifully, on calcareous incrustations): *Berggren*. Lyall Bay: *Reinbold* (amongst specimens sent Home by myself).

183. *Dactylmenia digitata*, J. Ag., Anal. Algol., cont. v., p. 52.

New Zealand: *(Agardh).*

184. *Dactylmenia laingii*, J. Ag., Anal. Algol., cont. v., p. 54.

Akatore: *R. M. L.* St. Clair, Green Island beach: *J. C. S.*

185. *Callophyllis calliblepharoides*, J. Ag., Epicr., p. 231. (*C. hombroniana*, Hook. and Harv., in Fl. Ant., tab. 72, fig. 2.)

Common along the east coast of the South Island from the Bluff to Banks Peninsula: *R. M. L.* Lyall Bay: *Reinbold* (amongst specimens sent Home by myself).

186. *Callophyllis hombroniana*, Mont. J. Ag., Epicr., p. 232. (*C. erosa*, Hook. and Harv., Fl. Nov.-Zel., p. 250, figs. 1, 3, and 4, but not 2.)

Probably the most abundant species of the genus, but Agardh's description is by no means satisfactory. Apparently common on the east coast of the South Island, but perhaps confused with other species.

187. *Callophyllis coccinea*. Fl. Nov.-Zel., p. 250.

Tauranga: *Davies*.

Var. *α carnea*, J. Ag., Bidr. Alg. Syst., part iv., p. 37. Chatham Islands: *Dr. Schauinsland*; *R. M. L.* Akatore, Lyttelton: *R. M. L.*

Var. *β crinalis*. St. Clair: *J. C. S.!*

188. *Callophyllis lambertii*, Turn. Hook. and Harv., in Lond. Journ.

New Brighton: *Dr. Schauinsland.*

It is very difficult to distinguish this species from the preceding, into which it passes.

189. *Callophyllis asperata.* Fl. Nov.-Zel., p. 250.

Cook Strait: *Lyall.*

I know nothing of this. It appears in Agardh's list of "Species inquirendæ."

190 *Callophyllis variegata.* Fl. Nov.-Zel., p. 250.

Tauranga: *Davies.*

C. variegata var. Paterson's Inlet: *R. M. L.* (identified by Reinbold).

191. *Callophyllis erosa.* Fl. Nov.-Zel., p. 250. (J. Ag., Epicr., p. 233.)

Double Corner: *R. M. L.* Bluff: *J. C. S.*

In both of these cases the identification is not quite certain.

192. *Callophyllis centrifuga*, J. Ag., Epicr., p. 688.

Bay of Islands: *Berggren.*

193. *Callophyllis decumbens*, J. Ag., Epicr., p. 688.

Bay of Islands: *Berggren.*

194. *Callophyllis tenera*,* J. Ag., Act. Holm., 1849, p. 87.

Dunedin and Banks Peninsula: *Berggren.* Moeraki, Lyall Bay: *R. M. L.*

195. *Ectophora depressa*, J. Ag., Epicr., p. 690.

Bay of Islands: *Berggren.*

196. *Ectophora dichotoma*, J. Ag., Epicr., p. 691.

Bay of Islands: *Berggren.*

Order **Spyridiaceæ.**

197. *Spyridia opposita.* Fl. Nov.-Zel., p. 256. (Anal. Algol., cont. iv., p. 14.)

Chalky Bay: *Lyall.*

Not recently collected, but not likely to have been mistaken for anything else.

198. *Spyridia biannulata*, J. Ag., Epicr., p. 267. (Anal. Algol., cont. iv., p. 13.)

Tauranga: *Berggren.*

Order **Areschougiaceæ.**

199. *Thysanocladia colensoi*, J. Ag., Epicr., p. 284. (Anal. Algol., cont. ii., p. 55.)

Cape Turnagain: *Colenso.* Hokianga: *Berggren.* Rangitoto Channel, Mongonui: *R. M. L.*

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* *Vide* note under 229, *Rhodophyllis erosa.*

Order **Champieæ.**

200. *Fauchea coronata(?),* J. Ag., Epicr., p. 294.
Bay of Islands: *Berggren.*

201. *Chylocladia secunda.* Fl. Nov.-Zel., p. 253. (J. Ag., Epicr., p. 297.)
Akaroa: *Raoul.* Port Cooper: *Lyall.*

202. *Chylocladia umbellata.* Fl. Nov.-Zel., p. 273, tab. 119c. (*Vide* also Anal. Algol., cont. iii., p. 75.)
Lyall Bay, Sumner (driftweed): *R. M. L.* Lyall Bay, Tauranga: *Berggren.*

203. *Chylocladia(?) cæspitosa.* Fl. Nov.-Zel., p. 253.
Port Nicholson: *Lyall.*
A very doubtful species.

Champia.

I have been considerably puzzled by the New Zealand species of this genus. Agardh (De Alg. mar. Nov.-Zel., p. 18) recognises only one, while in the "Flora Novæ-Zealandiæ" (p. 235) Harvey recognises three. Amongst my own specimens, which are fairly numerous, I have three forms; of these two perhaps which coincide with Harvey's *Champia novæ-zelandiæ* and *C. parvula* respectively, and the third is possibly distinct from any of Harvey's species. The only species admitted by Agardh is *Champia novæ-zelandiæ*, and it seems to me that this species properly defined should include both *Champia novæ-zelandiæ*, of Harvey, and *C. parvula*, of Harvey, for the following reasons: Agardh's specimens of *Champia novæ-zelandiæ* came from the Chatham Islands, and are apparently incomplete. He rightly distinguishes the juvenile from the mature form, but wrongly describes the whole frond as articulate. In the lower portions of the branches the articulations frequently quite disappear in the mature specimens. In the young frond, too, the stems inosculate, forming a dense tufted mass. In this form Raoul, who first identified the New Zealand form with *C. parvula*, probably mistook it for the European species, which it then resembles. I have a form from the Bay of Islands which Agardh thought might be a new species. It is but little branched; the branches are broader than in *Champia novæ-zelandiæ*, and the branchlets, particularly those bearing tetraspores, are more or less swollen and submoniliform. The branchlets, too, are rarely whorled, as in the *Champia novæ-zelandiæ*, but generally opposite. It may perhaps stand at present as a variety (*tumescens*) of *Champia novæ-zelandiæ.*

204. *Champia novæ-zelandiæ*, Hook. and Harv., London Journ., iv., p. 541. (J. Ag., Epicr., p. 306.)

Common throughout the North Island. Driftweed, at Sumner: *R. M. L.* Chatham Islands: *Travers.*

Champia novæ-zelandiæ var. *tumescens.* Bay of Islands: *R. M. L.*

Order **Rhodymeniaceæ.**

205. *Abroteia suborbicularis*, J. Ag., Epicr., p. 692. (*Nitophyllum(?) suborbiculare:* Fl. Nov.-Zel., p. 242.)

On *Carpophyllum maschalocarpum*, Blind Bay: *Lyall.* Hawke's Bay: *Colenso(?).* Tauranga: *Berggren*

206. *Hymenocladia lanceolata*, J. Ag., Epicr., p. 314. (*? Rhodymenia lanceolata*, Harv., Fl. Nov.-Zel., p. 248.)

Chatham Islands: *Travers.* Dunedin, Banks Peninsula: *Berggren.* Lower Green Island, Brighton (Otago), Lyttelton, Double Corner, Kaikoura, Lyall Bay: *R. M. L.*

207. *Chrysymenia saccata*, J. Ag., Anal. Algol., cont. v., p. 88.

Bluff, Warrington: *Berggren.*

208. *Chrysymenia apiculifera*, J. Ag., Epicr., p. 320.

Lyall Bay: *Berggren.* Oriental Bay, the Esplanade (Wellington), abundant: *R. M. L.*

209. *Chrysymenia(?) polydactyla.* Fl. Nov.-Zel., p. 253.

South Harbour: *Lyall.*

I know nothing of this.

209A. *Cordylecladia irregularis(?)*, Harv. J. Ag., Epicr., p. 328.

On fishermen's nets, Evans Bay, Wellington: *R. M. L.*

Major Reinbold, to whom I submitted the plant, says our species is very close to or the same as the American one.

210. *Rhodymenia leptophylla*, J. Ag., De Alg. N.Z. mar., p. 20. (*R. linearis*, Harv. *(partim?)*, Fl. Nov.-Zel., p. 248.)

Otago: *Lyall.* Chatham Islands: *Travers.* Tauranga, Bay of Islands: *Berggren.*

I have specimens of this and *R. linearis* from Lyttelton, Petone, Cape Kidnappers, and Mongonui, but so far I have not been able to distinguish the one from the other.

211. *Rhodymenia corallina.* Fl. Nov.-Zel., p. 248.

D'Urville Island and lat. 43°, East Coast: *Lyall.* Chatham Islands: *Travers.*

212. *Rhodymenia linearis*, J. Ag., Sp., p. 379.

Bay of Islands.

213. *Epymenia wilsonis*, Sond. J. Ag., Anal. Algol., p. 92. (*E. obtusa :* Fl. Nov.-Zel., p 249.)

Common along the east coast of New Zealand from Paterson's Inlet to Lyall Bay : *R. M. L.*

Epymenia obtusa is stated by Agardh (*loc. cit.*) to be confined to South Africa. He further emphasizes as one of the chief differences between *E. obtusa* and *E. wilsonis* that in *E. wilsonis* each fertile leaflet bears only one cystocarp, and in *E. obtusa* numerous ones. I find on specimens of what I take to be *E. wilsonis*, from Lyall Bay, that there are several—sometimes four or five—cystocarps on each leaflet, and these sessile when young, though provided with a very short pedicel when old. Evidently we have not as yet got a good definition of our common species of *Epymenia*.

214. *Epymenia acuta*, J. Ag., Epicr., p. 334. Anal. Algol., p. 93. Harv., Fl. Nov.-Zel., p. 249.

Akaroa : *Lyall.* Chatham Islands : (*Agardh*).

This is possibly only a form of the preceding. I have also a very distinct plant, apparently an *Epymenia*, from Wellington Harbour. Agardh considered it as probably new.

215. *Plocamium leptophyllum*, Kütz. J. Ag., Epicr., p. 338. (*Ploc. coccineum (partim)*, of Harvey.)

Dunedin, Banks Peninsula, Lyall Bay : *Berggren.* Petone : *R. M. L.* St. Clair : *J. C. S.*

Var. *strictum.* Kidnappers : *Hamilton !*

216. *Plocamium brachiocarpum*, Kütz. J. Ag., Epicr., p. 341. (*P. coccineum (partim)*, of Harvey and of Agardh.)

Bay of Islands : *Berggren.* The Bluff, Lyttelton, Wellington : *R M. L.* St. Clair : *J. C. S.*

217. *Plocamium abnorme.* Fl. Nov.-Zel., p. 246.

Lyall Bay : *Berggren.* Stewart Island, St. Clair : *J. C. S.*

218. *Plocamium dispermum*, Harv., Fl. Nov.-Zel., p. 246.

Foveaux and Cook Straits : *Lyall.* French Pass : *Dr. Schauinsland.* Akaroa Heads (in 8 fathoms) : *Suter !*

219. *Plocamium angustum.* Fl. Nov.-Zel., p. 246.

Common on the east coast of the South Island, and probably also in the North Island : *R. M. L.*

220. *Plocamium costatum.* Fl. Nov.-Zel., p. 246.

Common from the Bluff to Mongonui : *R. M. L.*

221. *Plocamium rigidum* (var.?), Bory, Bel. Voy., p. 142. (Major Reinbold, Sonder-Abdr. a Abh. Nat. Ver. Brem., 1899, bd. xvi., H. 2.)

French Pass : *Dr. Schauinsland.*

222. *Plocamium cruciferum.* Fl. Nov.-Zel., p. 246.

Bluff, Warrington, Dunedin, Banks Peninsula : *Berggren.* St. Clair : *J. C. S.*

223. *Plocamium dilatatum*, J. Ag., Epicr., p. 347.
Dusky Bay: *Forster*. Dunedin: *Berggren*.

224. *Rhodophyllis acanthocarpa*, Harv., Fl. Nov.-Zel., p. 251. (J. Ag., Epicr., p. 364.)
Patterson's Inlet, Lyttelton: *R. M. L.* Chatham Islands: *Travers*. Lyall Bay: *Reinbold* (amongst specimens sent Home by myself).

225. *Rhodophyllis gunnii*. Fl. Nov.-Zel., p. 247.
Preservation Harbour, Chalky Bay (West Coast): *Lyall*. Dunedin, Warrington, Banks Peninsula, Lyall Bay: *Berggren*. The Nuggets: *R. M. L.*

226. *Rhodophyllis(?) lacerata*, Harv., Fl. Nov.-Zel., p. 247.
Port William: *Lyall*.
Not recently identified.

227. *Rhodophyllis membranacea*. Fl. Nov.-Zel., p. 247 *(partim?)*. (J. Ag., Epicr., p. 365.)
A single specimen from the Bay of Islands: *Agardh*.

228. *Rhodophyllis(?) angustifrons*, Harv., Fl. Nov.-Zel., p. 247.
Port Nicholson and Bluff: *Lyall*.
Like the previous species, not recently identified, and but little known.

229. *Rhodophyllis erosa*, J. Ag., De Alg. N.Z. mar., p. 22. (*Callophyllis erosa*, Harv., Fl. Nov.-Zel., tab. 118, fig. 2.)
Bluff, Banks Peninsula, Bay of Islands: *Berggren*.
I am completely puzzled as to this plant from lack of fruiting specimens, and also from lack of literature. On sending a plant Home to Professor Agardh, he returned it as probably *Callophyllis tenera*, but as it was sterile he was not certain as to the accuracy of his determination. On sending from Lyall Bay what I believed to be the same species as the preceding to Major Reinbold, he determined it as *Craspedocarpus erosus* (Harv.) Schmitz = *Rhodophyllis erosa* (Harv.) J. Ag. = *Callophyllis erosa*, Harv., *partim*. The specimens sent to Major Reinbold bore tetraspores.

Order **Sphærococcoideæ.**

230. *Phacelocarpus labillardieri*. Fl. Nov.-Zel., p. 242. (J. Ag., Epicr., p. 399.)
Stated by earlier writers to be common; but this is certainly incorrect. The only specimens I have are from Lyall Bay, collected by myself, and some sent me from the neighbourhood of Castlepoint.

231. *Curdiæa coriacea*, J. Ag., Epicr., p. 401.; Anal. Algol., cont. iii., p. 95. (*Gracilaria coriacea*, Harv., Fl. Nov.-Zel., p. 243.)
Lyall Bay, Bay of Islands: *Lyall*. Bluff, Dunedin,

Lyall Bay : *Berggren.* Lyall Bay (? identification) : *R. M. L.*

232. *Curdiæa laciniata,* J. Ag., Epicr., p. 402. (Harvey Gibson, Journ. of Bot., 1893, p. 161.)
Bay of Islands, Cook Strait : *Lyall.* Otago : *Lindsay.*

233. *Melanthalia abscissa.* Fl. Nov.-Zel., p. 242.
Common from Bluff to Mongonui : *R. M. L.*

234. *Gracilaria harveyana,* J. Ag., Bidr. Alg. Syst., p. 59.
Chatham Islands : *Dr. Schauinsland.*
Specimens sterile, and the identification therefore somewhat doubtful.

235. *Gracilaria flagellifera,* J. Ag., Epicr., p. 412.
Chatham Islands : *Travers.*

236. *Gracilaria confervoides.* Fl. Nov.-Zel., p. 243.
Everywhere common : *R. M. L.*

237. *Gracilaria dura,* J. Ag., Sp., p. 589.
Bluff : *Berggren.* Dunedin(?) : *Professor Parker.*

238. *Gracilaria secundata(?),* J. Ag., Epicr., p. 418.
Moeraki, Taylor's Mistake : *R. M. L.* Otago Harbour : *J. C. S.*
This plant is abundant at the above-named localities, so that it is surprising that it has not been previously collected. As yet, however, it is very imperfectly identified. On sending specimens to Professor Agardh he returned them as *G. disticha.* Major Reinbold, however, regards the plant as possibly *G. secundata.* There is no question but that Professor Agardh was wrong in identifying it as *G. disticha.*

239. *Gracilaria multipartita* var. *polycarpa.* Fl. Nov.-Zel., p. 243. (J. Ag., Bidr. Alg. Syst., iv., p. 62.)
Blind Bay : *Lyall.*

240. *Sarcodia crateriformis,* J. Ag., Epicr., p. 697.
Hokianga, Bay of Islands : *Berggren.*
(*Vide* also J. Ag., Bidr. Alg. Syst., iv., p. 59.)

241. *Sarcodia montagneana.* Fl. Nov.-Zel., p. 242.
Bay of Islands : *Lyall ; Berggren.* Mongonui : *R. M. L.*
Berggren also obtained a few fragments at Lyall Bay.

242. *Gracilaria ramulosa,* J. Ag., Epicr., p. 417. (Harvey Gibson, Journ. of Bot., 1893, p. 161.)
New Zealand : *Professor Parker.*

243. *Calliblepharis prolifera,* J. Ag., Epicr., p. 432. (*Rhodymenia prolifera :* Fl. Nov.-Zel., p. 249.)
Hawke's Bay : *Colenso.* Bay of Islands : *Berggren.*

244. *Calliblepharis(?) tenuifolia,* Harv., Fl. Nov.-Zel., p. 243.
Chalky Bay : *Lyall.*

245. *Dicranema aciculare*, J. Ag., Epicr., p. 436.
Warrington : *Berggren.*

Order **Delesseriæ.**

246. *Nitophyllum berggrenianum*, J. Ag., Sp. Alg., vol. iii., part iii., p. 55.
Tauranga, Bay of Islands: *Berggren.*

247. *Nitophyllum variolosum.* Fl. Nov.-Zel., p. 241.
Port Cooper, Banks Peninsula: *Lyall.* East Coast: *Colenso.*

Agardh (Sp. Alg., vol. iii., part iii., p, 55) considers that the plant he formerly identified as *N. variolosum*, of Harvey, probably belongs to another genus, perhaps *Rhodymenia.* On a specimen sent by me from Lyttelton he writes, " Videtur planta eadem quam N. variolosum olim credidi, quam hodie suspicor Rhodymenia(?) [this word is almost illegible]. Specimen cystocarpiis mihi exoptatum.

248. *Nitophyllum gattyanum*, J. Ag., Sp. Alg., vol. iii., p. 59.
Agardh (Anal. Algol., cont. iv., p. 41) states that Baron Von Mueller sent him specimens of this plant from New Zealand.

249. *Nitophyllum undulatissimum*, J. Ag., Sp. Alg., vol. iii., part iii., p. 59.
Sent from the shores of New Zealand to Agardh by Baron Von Mueller.

250. *Nitophyllum denticulatum*, J. Ag., Sp. Alg., vol. iii., part iii., p. 41.
Blind Bay, Cook Strait: *Lyall.* Maketu: *Chapman.* Tauranga: *Berggren ; Davies.*

251. *Nitophyllum decumbens*, J. Ag., Epicr., p. 458. (Also Sp. Alg., vol. iii., part iii., p. 64.)
Var. *fucicola.* Dunedin and Lyall Bay: *Berggren.* Paterson's Inlet: *R. M. L.*

252. *Nitophyllum uncinatum*, J. Ag., Epicr., p. 465. (Also Sp. Alg., vol. iii., part iii., p. 65.)
Blind Bay: *Lyall.* Bluff, Lyall Bay, Hokianga: *Berggren.* Cape Kidnappers: *A. Hamilton.* Stewart Island: *J. C. S.*

253. *Nitophyllum harveyanum*, J. Ag., Epicr., p. 462. (*N. palmatum* var. *pinnatifidum*: Fl. Nov.-Zel., p. 240.)
Bluff to Banks Peninsula: *Berggren.*

254. *Nitophyllum palmatum*, J. Ag., Epicr., p. 462. (Also Alg. Sp., vol. iii., part iii., p. 79.)
Chatham Islands: *Travers.* East Coast: *Lyall.* Lyall Bay: *R. M. L.* (identified by Major Reinbold).

255. *Nitophyllum polyglossum*, J. Ag., Sp. Alg., vol. iii., part iii., p. 79.

On the shores of New Zealand: *(Agardh)*.

256. *Nitophyllum semicostatum*, J. Ag., Epicr., p. 699. (Sp. Alg., vol. iii., part iii., p. 80.)

Dunedin: *Berggren*. Akatore, Brighton, St. Clair: *R. M. L.* I have a fragment apparently belonging to this species from Kekerangu.

257. *Nitophyllum d'urvillei*. Fl. Nov.-Zel., p. 240.

This species was formerly confused with the preceding by Agardh and Harvey, but Agardh states (Sp. Alg., vol. iii., part iii., p. 80) that he is compelled to say that he has not seen any specimens of this plant, and further considers that he cannot give any opinion as to its identity from an examination of the original figure (Bory, Voy. "Coquille," tab. 19, fig. 1).

258. *Nitophyllum multinerve*, J. Ag., Epicr., p. 464. (Sp. Alg., vol. iii., part iii., p. 57.)

Massacre Bay, Chalky Bay: *Lyall*. Tauranga: *Berggren*. Paterson's Inlet, Akatore, St. Clair: *R. M. L.*

259. *Nitophyllum minus*. Fl. Nov.-Zel., p. 241. (J. Ag., Sp. Alg., vol. iii., part iii., p. 66.)

Not recently collected. It may be doubted whether the form reported from New Zealand is that originally described by Sonder.

260. *Nitophyllum smithii*, Hook. and Harv., Crypt. Anat. Ant., tab. 178. (J. Ag., Epicr., p. 454.)

Chatham Islands, Dunedin Wharf: *R. M. L.*

261. *Nitophyllum dilapidum*, J. Ag., Sp. Alg., vol. iii., part iii., p. 77.

Sent from New Zealand to Agardh by Baron F. von Mueller.

262. *Nitophyllum(??) microphyllum*, Crosby Smith (*Mscr.*).

On the back of a *Haliotis* shell, Green Island beach: *J. C. S.*

Mr. Crosby Smith has furnished me with the following description of this plant, which seems to be a new and distinct species, belonging perhaps to a new genus. In all particulars except one it belongs to Agardh's tribe *Monantheæ*, sub-genus *Aglæophyllum*, genus *Nitophyllum*; but, though in its vegetative structure its place is exactly here, its cruciately divided tetraspores would seem to throw it outside the genus *Nitophyllum* altogether. I have, however, retained it here for the present, marking the genus with two queries. The discovery and examination of the cystocarps may help to determine its position more exactly. I have deposited specimens in the Canterbury Museum.

Sub-genus *Aglæophyllum*, J. Ag., Sp. Alg., vol. iii., part iii., p. 38. Tribe *Monantheæ*, J. Ag., *loc. cit.*, p. 46: "*Nitophyllum microphyllum*, Crosby Smith (*Mscr.*). Root an irregularly creeping rhizome. Fronds clustered, many from the same base, ecostate, stipitate, linear clavate, obtuse, 3–15 mm. long, distantly toothed or proliferously pinnate. The principal frond is often abruptly terminated, and from its apex springs a secondary leaflet similar to the primary one, and proliferous from the margin. Sori solitary in the terminal expanded lobes, and girt round by a sterile margin, the fertile portion expanding into an ovate, obovate, rotundate, or very irregular lamina. The tetraspores are cruciately divided, thus apparently distinguishing the plant from all others of the order. Colour when fresh bright-red, and on drying much darker. Substance membranous. This seaweed was found on a *Haliotis* shell on the Green Island beach. It completely covered the shell in a moss-like fashion. I have given it the specific name *Microphyllum*, as it is, so far as my knowledge serves, the smallest of the genus."

From the above description and classification it will be seen that the plant probably comes nearest to the Australian *N. monanthos*, J. Ag. (Sp. Alg., p. 655), from which, however, it differs in many ways—in the smaller size, the almost entire margin, the shape of the fronds, and, above all, in the cruciately divided tetraspores.

263. *Nitophyllum affine*, Harv., in Hook. Journ., 1844, p. 447. (J. Ag., Epicr., p. 456; Sp., vol. iii., part iii., p. 68.)

264. *Schizoneura dichotoma*, J. Ag, Sp. Alg., vol. iii., part iii. (*Delesseria dichotoma*: Fl. Nov.-Zel., p. 239; J. Ag., Epicr., p. 480.)

Ruapuke and Chalky Bay: *Lyall.* Chatham Islands: *Dr. Schauinsland.*

265. *Schizoneura davisii*, J. Ag., Sp. Alg., vol. iii., part iii., p. 168. (*Delesseria davisii*: Fl. Nov.-Zel., p. 239; J. Ag., Epicr., p. 480.)

Ruapuke, Preservation Harbour, Chalky Bay: *Lyall.* St. Clair: *R. M. L.*; *J. C. S.* Wyckliffe Bay: *J. C. S.*

266. *Schizoneura hookeri*, J. Ag., Sp. Alg., vol. iii., part iii., p. 168. (*D. hookeri*: Fl. Nov.-Zel., p. 238.)

Lyall Bay, Foveaux Strait: *Lyall.*

Mr. Smith has obtained a specimen of this at Riverton, and also when trawling outside Otago Heads; and I found what can scarcely be anything else than a fragment of this magnificent species at the Signal-station, Wellington Heads. What was apparently another fragment was found by Mr. Smith in the baths at St. Clair.

267. *Schizoneura quercifolia,* J. Ag., Sp. Alg., vol. iii., part iii., p. 168. (*Delesseria quercifolia :* Fl. Nov.-Zel., p. 239 ; J. Ag., Epicr., p. 481.)

East Coast, lat. 43°: *Lyall.* Dunedin Wharf: *R. M. L.; J. C. S.*

268. *Schizoneura laurifolia,* J. Ag., Sp. Alg., vol. iii., part iii., p. 168.

The Nuggets : *R. M. L.*

A very rare plant apparently.

269. *Pteridium(?) pleurosporum,* J. Ag., Sp. Alg., vol. iii., part iii., p. 226. (*Delesseria pleurospora :* Fl. Nov.-Zel., p. 239.)

A species not recently collected in New Zealand. Agardh hesitatingly refers it to the new genus.

Preservation Harbour : *Lyall.*

270. *Hemineura cruenta,* Harv., Fl. Nov.-Zel., p. 240. (J. Ag., Sp Alg., vol. iii., part iii., p. 110, footnote.)

Massacre Bay : *Lyall.*

A little-known species and not recently collected.

271. *Apoglossum oppositifolium,* J. Ag., Sp. Alg., vol. iii., p. 193. (*Delesseria oppositifolia,* Harv., Fl. Nov.-Zel., p. 339 ; J. Ag., Epicr., p. 491.)

Stewart Island (rare) : *Lyall.*

272. *Apoglossum montagneanum. Delesseria montagnea,* J. Ag., Epicr., p. 492 ; Sp. Alg., vol. iii., p. 194.

Tauranga : *Berggren.*

273. *Apoglossum ruscifolia,* J. Ag., Sp. Alg., vol. iii., part iii., p. 194. (*Delesseria ruscifolia :* Fl. Nov.-Zel., p. 239.)

Blind Bay : *Lyall.*

274. *Phitymophora linearis.* (*P. laingii,* J. Ag., Sp. Alg., vol. iii., part iii., p. 173. *Delesseria linearis,* R. M. L., Trans. N.Z. Inst., vol. xxix., p. 449.)

Lyall Bay, Moeraki (very rare) : *R. M. L.*

After describing this plant under the name *Delesseria linearis,* I sent specimens to Professor Agardh, who unfortunately, not identifying it with my description, renamed it *Phitymophora laingii.*

275. *Delesseria nereifolia.* Fl. Nov.-Zel., p. 239.

Preservation Harbour and east coast of Stewart Island : *Lyall.*

276. *Delesseria crassinervia,* Mont., Voy. au Pôle Sud, 164, t. 8, f. 1. Harv., Fl. Nov.-Zel., p. 239 ; R. M. L., Trans. N.Z. Inst., vol. xxix., p. 448.

St. Clair, Wyckliffe Bay : *R. M. L. ; J. C. S.* Trawling outside Otago Heads : *J. C. S.*

I ventured (*loc. cit.*) to identify a species of *Delesseria* with *D. crassinervia.* Agardh (Sp. Alg., vol. iii., part iii., p. 217) animadverts on my criticism of his treatment of the species *D. crassinervia,* and states that he is altogether doubtful as to the identity of my plant. He suggests again that *D. crassinervia,* Mont., may be *Nitophyllum endiviæfolium.* Whether my plant is identical with that of Montagne may perhaps be left an open question in the absence of his type specimens, but it seems to me to agree better with his description than any other species which I know does. Agardh (Epicr., p. 496) points out that *D. crassinervia,* Hook. and Harv., is in part *D. epiglossum,* J. Ag., and again refers to this in Sp. Alg., vol. iii., part iii., p. 218; but my plant is certainly quite distinct from *D. epiglossum.* Further, I have a specimen of *N. endiviæfolium* sent me from Victoria by Mr. H. T. Tisdall, and this is certainly also distinct from *D. crassinervia.* It is possible my species may be *Apoglossum montagneanum,* J. Ag., of which I have seen no specimen; but, judging from the published descriptions, it differs considerably also from this. Since describing it previously I have observed the cystocarps but not examined them microscopically; they are solitary, and placed on the veins of the leaflets. It must be admitted that my photographs as they appear in the "Transactions of the New Zealand Institute" (vol. xxix.) perhaps justify Agardh's criticism of them.

277. *Caloglossa leprieurii,* J. Ag., Epicr., p. 499. (J. Ag.(?), Sp. Alg., vol. iii., part iii., p. 228. *Delesseria leprieurii:* Fl. Nov.-Zel., p. 240.)

Bay of Islands: *Hooker; Berggren.*

Order **Helminthocladiaceæ.**

278. *Helminthocladia polymorpha (vel lanceolata).*

Lyall Bay: *R. M. L.*

Major Reinbold thus names a plant sent from Lyall Bay by myself, but I can find no published description of it in the literature accessible to me.

279. *Batrachospermum* sp.

B. moniliforme, Roth., is described as occurring in New Zealand (Fl. Nov.-Zel, p. 261) in the fresh-water streams of Canterbury. I have specimens collected in a tributary of the Avon crossing the Ilam Road by Robert Brown and myself, but the species is distinct from the European *moniliforme,* and possibly new.

280. *Nemalion ramulosum.* Fl. Nov.-Zel., p. 245. (J. Ag., Epicr., p. 508; Harvey Gibson, Journ. of Bot., 1893, p. 161.)

Otea: *Lyall.* Brighton or Lyall Bay: *Professor Parker.*

I have a species of *Nemalion* from the Rangitoto Channel, which may be the same.

Order **Chætangieæ.**

281. *Chætangium variolosum*, J. Ag., Epicr., p. 539.
St. Clair: *J. C. S.*
Identified by Professor Agardh from specimens sent Home by Mr. Crosby Smith.

282. *Scinaia furcellata.* Fl. Nov.-Zel. p. 245. (J. Ag., Epicr., p. 512.)
Hokianga, Bay of Islands: *Berggren.*

283. *Apophlœa sinclairii*, J. Ag., Epicr., p. 637. (Fl. Nov.-Zel., p. 244.)
Bay of Islands, Mongonui, Whangaroa: *R. M. L.*
I have also a fragment from one of the West Coast sounds (Milford Sound, I think), given to me by Captain Hutton. This would seem to point to a curiously discontinuous distribution.

284. *Apophlœa lyallii*, J. Ag., Epicr., p. 538.
Preservation Harbour: *Lyall.* Bluff, Tauranga: *Berggren.* Common along the east coast of Otago from the Bluff to Seacliff: *R. M. L.; J. C. S.*

Order **Gelideæ.**

285. *Gelidium longipes*, J. Ag., Epicr., p. 547.
Bay of Islands: *Berggren.*

286. *Gelidium caulacantheum*, J. Ag., Epicr., p. 548. (? *G. corneum* var. *subulifolium*: Fl. Nov.-Zel., p. 243.)
Tauranga, Hokianga, Bay of Islands, Auckland: *Berggren.* Taylor's Mistake, Wellington Harbour: *R. M. L.*

287. *Gelidium corneum*, J. Ag., Epicr., p. 548. (Fl. Nov.-Zel., p. 243.)
Hawke's Bay: *Colenso.* Banks Peninsula: *Lyall.* Bay of Islands, Hokianga, Napier, Lyall Bay: *Berggren.* Lyttelton, Lyall Bay: *R. M. L.*
This cosmopolitan species has been subdivided by Bornet, but in the absence of literature I am unable to determine how the forms we have in New Zealand should be named.

288. *Pterocladia lucida.* Fl. Nov.-Zel., p. 244. (J. Ag., Epicr., p. 545.)
Hokianga, Bay of Islands, Lyall Bay: *Berggren.* Common along the east coast from Kaikoura to Mongonui: *R. M. L.*
Another very variable plant, perhaps including several species.

Order **Hypneaceæ.**

289. *Hypnea musciformis.* Fl. Nov.-Zel., p. 244. (J. Ag., Epicr., p. 561.)
Tauranga: *Berggren.*
The occurrence of this plant in New Zealand is doubtful, as Berggren's specimens were not complete, and it was received into the Fl. Nov.-Zel. on the authority of Banks. I have seen no specimens of it.

Order **Solieriæ.**

290. *Caulacanthus spinellus.* Fl. Nov.-Zel., p. 244. (J. Ag., Epicr.: *C. ustulatus* var. (?) *spinella.*)
Bay of Islands: *Berggren.* Petone, Lyall Bay: *R. M. L.* St. Clair, Green Island, Bluff, &c.: *J. C. S.*

291. *Catenella opuntia.* Fl. Nov.-Zel., p. 254.
Hokianga: *Berggren.*
Var. *fusiformis,* J. Ag., Epicr., p. 588. Chatham Islands, Puketeraki: *J. C. S.*

292. *Catenella oligarthra,* J. Ag., Epicr., p. 587.
Bay of Islands: *Berggren.*

Order **Chondrieæ.**

293. *Laurencia gracilis.* Fl. Nov.-Zel., p. 234.
East Coast: *Colenso.*

294. *Laurencia virgata.* Fl. Nov.-Zel., p. 234.
Cape Kidnappers, Parimahu: *Colenso.* French Pass: *Dr. Schauinsland.* Hauraki Gulf, Banks Peninsula: *Lyall.* Hokianga, Bay of Islands: *Berggren.* Bay of Islands, Mongonui: *R. M. L.*

295. *Laurencia distichopyhlla.* Fl. Nov.-Zel., p. 234.
Hawke's Bay, Parimahu: *Colenso.* French Pass: *Dr. Schauinsland.* Waitemata Harbour: *Lyall.* Bay of Islands: *Hooker,* &c. Hokianga: *Berggren.* Kai-iti Beach (Gisborne): *R. M. L.*

296. *Laurencia thyrsifera,* J. Ag., Epicr., p. 654.
Chatham Islands: *Dr. Schauinsland,* &c.

297. *Laurencia elata.* Fl. Nov.-Zel., p. 233.
East Coast: *Colenso.*
This plant has not been recently collected in New Zealand, and its occurrence here may be regarded as doubtful.

298. *Laurencia botrychioides.* Fl. Nov.-Zel., p. 234.
Bay of Islands: *Hooker; Berggren.* Parimahu: *Colenso.*

299. *Laurencia hybrida,* J. Ag., Epicr., p. 655. (*? L. cæspitosa:* Fl. Antarct., i., 184.)
Akatore: *R. M. L.*

Identification due to Major Reinbold.

Other species of *Laurencia* are to be found in New Zealand, but they are as yet insufficiently well known. Harvey gives *Laurencia pinnatifida* as occurring in the Auckland Islands, and I have badly preserved specimens from Cook Strait and Dunedin Heads which may possibly belong to this species.

299A. *Laurencia heteroclada*, J. Ag., Epicr., p. 648.
Kai-iti Beach (Gisborne): *R. M. L.*

300. *Chladymenia lyallii.* Fl. Nov.-Zel., p. 235.
Bay of Islands: *Berggren; Lyall.*

301. *Chladymenia oblongifolia.* Fl. Nov.-Zel., p. 235.
Apparently common from Banks Peninsula to Bay of Islands: *R. M. L.* Hokianga: *Berggren.* Chatham Islands: *(Agardh; R. M. L.).*

302. *Ptilonia magellanica.* Fl. Nov.-Zel., p. 233.
East Coast: *Lyall.*
Not recently collected in New Zealand.

303. *Asparagopsis armata.* (*Asparagopsis delilei*, Fl. Nov.-Zel., p. 233; J. Ag., Epicr., p. 666.)
Dredged at D'Urville Island: *Lyall.* Lyall Bay (driftweed), Taylor's Mistake: *R. M. L.* Chatham Islands: *Dr. Schauinsland.* Dusky Sound: *J. C. S.*

304. *Delisea elegans.* Fl. Nov.-Zel., p. 233.
Dredged at Preservation Harbour and Akaroa: *Lyall.* Dredged in 8 fathoms, Akaroa: *H. Suter!* Wellington Harbour (driftweed): *R. M. L.* St. Clair, Owaka, Stewart Island: *J. C. S.*

305. *Delisea pulchra*, Grev. J. Ag., Epicr., p. 671.
Bay of Islands: *Berggren.*
Only a single specimen has as yet been found in New Zealand.

Order **Wrangelieæ.**

306. *Wrangelia lyallii.* Fl. Nov.-Zel., p. 236.
Ruapuke and Preservation Harbour: *Lyall.*

307. *Wrangelia squarrulosa.* Fl. Nov.-Zel., p. 236.
St. Clair: *J. C. S.* Preservation Harbour: *Lyall.*
(*Vide* also J. Ag., Epicr., p. 25, under "*Ceramium confusum,*" and p. 52.)

Order **Rhodomeleæ.**

The species of this order are perhaps less well known than those of most of the preceding orders. Some of the genera (*e.g.*, *Polysiphonia*, *Rhodomela*) present unusual difficulties, though even where the species are well defined but little work seems to have been done upon them.

Chondriopsis.

Our New Zealand species are common, but as yet very imperfectly described. I have many specimens of this genus, including at least three species; but none of the species represented agree altogether satisfactorily with any of Harvey's descriptions, yet two at least of them are very common. (For the limits of the genus, *vide* J. Ag., Bidr. Alg. Syst., iv., p. 89.)

308. *Chondriopsis (Chondria) flagellaris.* Fl. Nov.-Zel., p. 222.

Port Nicholson, Paterson's Harbour: *Lyall.*

309. *Chondriopsis (Chondria) macrocarpa.* Fl. Nov.-Zel., p. 223. (J. Ag., Anal. Algol., p. 148.)

Foveaux Strait: *Lyall.* Otago: *Lindsay.* Warrington, Dunedin, Banks Peninsula: *Berggren.* Chatham Islands: *Dr. Schauinsland.* Lyttelton, Pigeon Bay, Double Corner (Amberley): *R. M. L.*

I have some specimens from Brighton (Otago) which may belong to this species, but more probably to a new and undescribed one.

310. *Chondriopsis capensis(?).* Harv., Ner. Austr., p. 86. (J. Ag., Anal. Algol., p. 149.)

Some specimens collected by Mr. Crosby Smith at St. Clair are considered by Agardh to come nearer to this than to any other described species.

311. *Bostrychia mixta.* Fl. Nov.-Zel., p. 225. (J. Ag., Anal. Algol., cont. iv., p. 69.)

Bay of Islands: *Hooker.* Otago: *Lyall.* Invercargill Jetty, Cape Saunders (identification uncertain): *J. C. S.*

It may be doubted whether our plant comes within the stricter limits of the species described by Agardh (*loc. cit.*).

312. *Bostrychia laingii*, J. Ag., Anal. Algol., *loc. cit.*, p. 72.

Otago Harbour: *J. C. S.*

In a footnote to this species Agardh refers to a *B. disticha* as occurring on the New Zealand coasts; of this I know nothing.

313. *Bostrychia novæ-zelandiæ*, J. Ag., *loc. cit.*, p. 75.

St. Clair: *J. C. S.*

314. *Bostrychia cæspitula*, J. Ag., *loc. cit.*, p. 81.

Middle Island of New Zealand: *J. Dall.*

Sent to Agardh by Baron Von Mueller.

315. *Bostrychia harveyi*, Mont.(?). Harv., Phyc. Austr., pl. 252. (J. Ag., *loc. cit.*, p. 80.)

Paterson's Harbour, Wellington, Banks Peninsula: *Lyall.* Warrington, Banks Peninsula, Bay of Islands: *Berggren.* Island Bay: *T. Kirk!* Invercargill Jetty: *J. C. S.*

316. *Bostrychia arbuscula.* Fl. Nov.-Zel., p. 226.
Bluff, Warrington, Dunedin, Banks Peninsula: *Berggren.* Brighton (Otago), Lower Green Island beach: *R. M. L.* Probably common along the East Coast of the South Island: *R. M. L.*

317. *Bostrychia rivularis (?),* Harv. J. Ag., Anal. Algol., cont. iv., p. 75.
I found a species of *Bostrychia* growing abundantly immediately underneath the waterfall in Long Bay, near Akaroa Heads. On forwarding some of it to Agardh, he considered it was perhaps the same as the American *B. rivularis*, but see footnote on *B. simpliuscula* (J. Ag., *loc. cit.*, p. 73).

318. *Rhodomela cæspitosa.* Fl. Nov.-Zel., p. 225.
Parimahu, &c.: *Colenso.* Bluff: *Berggren.*

319. *Rhodomela gaimardi.* Fl. Nov.-Zel., p. 225.
Hawke's Bay: *Colenso.* Blind Bay, Akaroa: *Lyall.*

320. *Rhodomela traversiana,* J. Ag., De Alg. N.Z. mar., p. 28.
Chatham Islands: *Travers.* Bluff: *Berggren.* New River Heads, Brighton (Otago), Lower Green Island beach, Moeraki: *R. M. L.*
It is but right to say that, on forwarding some of my specimens to Agardh, he identified them merely as belonging to the genus *Rhodomela*, but refused to give them a specific name, as they were rather imperfect; but there is certainly abundant in Otago a species of *Rhodomela* which agrees well with Agardh's description of *R. traversiana.* The same plant is found from the Bluff to Moeraki, and if not *R. traversiana* is an undescribed species.

Polysiphonia.

Our New Zealand list for this genus is still very far from completion, and I have many plants of the genus which I am quite unable to name. Some of these are probably new. The following list can only be regarded as tentative. I have left out a considerable number of species unknown to Agardh or regarded by him as doubtful, though previously described from New Zealand. One or two of these are British, and probably represent wrongly identified New Zealand forms; of the others none have been recently collected, and may be left in abeyance until found again and redetermined. Here, as elsewhere, I have not introduced any fresh species to the list on my own authority alone, nor have I attempted to classify the species under any of the sub-genera; the references given will enable the investigator to do so for himself.

321. *Polysiphonia dendritica.* Fl. Nov.-Zel., p. 232.
Napier, Bay of Islands: *Berggren.* New Zealand: *Professor Parker.*

322. *Polysiphonia colensoi.* Fl. Nov.-Zel., p. 229, pl. 122c.
Lyall Bay: *Berggren.* Chatham Islands: *Dr. Schauinsland.*

323. *Polysiphonia ceratoclada.* Fl. Nov.-Zel., p. 232.
Banks Peninsula, Lyall Bay: *Lyall.* Lyall Bay: *Berggren.*

324. *Polysiphonia simplicifilum,* J. Ag., De Alg. N.Z. mar., p. 28.
Bay of Islands: *Berggren.*

325. *Polysiphonia pennata.* Fl. Nov.-Zel., p. 231.
Cape Kidnappers: *Colenso.* Lyall Bay: *Berggren.*

326. *Polysiphonia abscissa.* Fl. Nov.-Zel., p. 227.
Akaroa: *Raoul; Lyall.* Blind Bay, Paterson's Harbour: *Lyall.* Warrington: *Berggren.*

327. *Polysiphonia strictissima.* Fl. Nov.-Zel., p. 227.
New Zealand: *Raoul.* Chatham Islands: *Dr. Schauinsland.*

328. *Polysiphonia variabilis.* Fl. Nov.-Zel., p. 228.
Blind Bay, Port Nicholson, Otago: *Lyall.* Tauranga: *Davies; Berggren.*

329. *Polysiphonia lyalli.* Fl. Nov.-Zel., p. 231.
Preservation Harbour, Foveaux Strait: *Lyall.* Hawke's Bay, &c.: *Colenso.* Bluff, Warrington, Lyall Bay: *Berggren.*

330. *Polysiphonia isogona.* Fl. Nov.-Zel., p. 231.
Blind Bay: *Lyall.* Cape Kidnappers: *Colenso.* Tauranga: *Berggren.*

331. *Polysiphonia comoides.* Fl. Nov.-Zel., p. 231.
Akaroa, Port Cooper: *Lyall.* Tauranga: *Berggren.*

332. *Polysiphonia corymbifera.* Fl. Nov.-Zel., p. 231.
Maketu: *Chapman.* Warrington: *Berggren.*

333. *Polysiphonia decipiens,* Mont. (*Vide* J. Ag., De Alg. N.Z. mar., p. 29.)
Bay of Islands: *Berggren.* Otago Harbour: *J. C. S.*

334. *Polysiphonia aterrima.* Fl. Nov.-Zel., p. 230.
Warrington, Dunedin, Banks Peninsula, Lyall Bay: *Berggren.* Taylor's Mistake, Wellington Harbour: *R. M. L.*

335. *Polysiphonia ramulosa.* Fl. Nov.-Zel., p. 230.
Parimahu: *Colenso.* Bluff: *Berggren.*

336. *Polysiphonia botryocarpa.* Fl. Nov.-Zel., p. 230.
Otago, Foveaux Strait: *Lyall.*

337. *Polysiphonia muelleriana*, J. Ag., Alg. Chatham.
Stewart Island, Port Cooper, Banks Peninsula: *Lyall.* Chatham Islands: *Travers.* Lyall Bay(?): *R. M. L.*

338. *Polysiphonia implexa.* Fl. Nov.-Zel., p. 229.
Akaroa: *Raoul.* Cape Kidnappers and Parimahu: *Colenso.* St. Clair: *J. C. S.*

339. *Polysiphonia roeana*, J. Ag., Sp. Alg., vol. ii., part iii., p. 967.
St. Clair: *J. C. S.*

340. *Polysiphonia cancellata.* Fl. Nov.-Zel., p. 230.
Banks Peninsula: *Lyall.* Stewart Island: *R. M. L.*

341. *Polysiphonia mallardiæ*, J. Ag., Sp. Alg., vol. ii., part iii., p. 1020. (Harvey Gibson, Journ. of Bot., 1893.)
Taylor's Mistake, Double Corner (Amberley): *R. M. L.* New Zealand: *Professor Parker.* St. Clair (common): *J. C. S.*

342. *Polysiphonia hookeri*, J. Ag., Sp. Alg., vol. ii., part iii., p. 1019. (Harv., Ner. Austr., p. 40.)
Akatore, Green Island beach, Lyall Bay: *R. M. L.* Wyckliffe Bay: *J. C. S.*

343. *Polysiphonia hystrix*, J. Ag., Sp. Alg., vol. ii., part iii., p. 1017. (Harvey Gibson, Journ. of Bot., 1893.)
New Zealand (probably Brighton): *Professor Parker.*
Probably the plant so identified by Professor Harvey Gibson is the same as that identified above by Professor Agardh as *P. hookeri*, but as I have none of Harvey Gibson's specimens at hand I keep the two species separate.

344. *Polysiphonia gaudichaudii*, J. Ag., Sp. Alg., vol. ii., part iii., p. 1060. (Harvey Gibson, Journ. of Bot., June, 1893.)
New Zealand: *Professor Parker.*

345. *Polysiphonia cloiophylla*, J. Ag., Sp. Alg., vol. ii., part iii., p. 934.
Var. *corymbosa*, Harvey Gibson, Journ. of Bot., June, 1893.
New Zealand (? Brighton): *Professor Parker.*

346. *Polysiphonia heteroclada*, J. Ag., Bidr. Syst., iv., p. 98. (Reinbold, Sonder-Abdr. a. Abh. Nat. Ver. Brem., 1899, bd. xvi., H.2, p. 296.)
New Zealand: *(Agardh).* Chatham Islands: *Dr. Schauinsland.*

347. *Polysiphonia dumosa*, Hook. and Harv., Fl. Antarct., 182, t. 75 (Reinbold, *loc. cit.*).
Chatham Islands: *Dr. Schauinsland.*

348. *Polysiphonia frutex*, J. Ag., Sp. Alg., vol. ii., part iii., p. 1047.
Wyckliffe Bay: *J. C. S.*

349. *Polysiphonia blandi*, J. Ag., Sp. Alg., vol. ii., part iii., p. 976.
Petone: *R. M. L.* St. Clair, Otago Harbour: *J. C. S.*

350. *Polysiphonia monilifera*, Hook. and Harv. (J. Ag., Sp. Alg., p. 927.)
Paterson's Inlet: *R. M. L.*
The identification is due to Major Reinbold.

351. *Polysiphonia infestans(?)*, Harv., Mar. Bot. of West. Austr., p. 539. (J. Ag., Sp. Alg., vol. ii., part iii., p. 959.)
St. Clair: *J. C. S.*
Some specimens collected by myself at Petone are somewhat doubtfully referred to this species by Agardh.

352. *Polysiphonia caulescens*, J. Ag., Anal. Algol., cont. iii., p. 111.
St. Clair: *J. C. S.* Chatham Islands: *Travers.*

353. *Polysiphonia versicolor*, J. Ag., Sp. Alg., vol. ii., part iii., p. 927. (Anal. Algol., cont. iii., p. 111.)
St. Clair: *J. C. S.*
Other species not included in this list, and doubtfully identified by Agardh from specimens sent Home by Mr. Crosby Smith and myself, are *P. ferulacea*, *P. neglecta.*

354. *Rytiphlœa delicatula.* Fl. Nov.-Zel., p. 228, pl. 112.
Cook Strait and Akaroa: *Lyall.*
This species has not been collected recently.

355. *Lenormandia chauvini.* Fl. Nov.-Zel., p. 222 (excluding variety). (J. Ag., Anal. Algol., p. 169.)
Bluff, Lyall Bay, Bay of Islands: *Berggren.* Worser Bay: *R. M. L.* Otago Harbour, St. Clair: *J. C. S.*

356. *Lenormandia angustifolia*, J. Ag., Alg. N.Z. mar.; Anal. Algol., p. 169.
Bluff, Dunedin, Lyall Bay, Bay of Islands: *Berggren.* Brighton (Otago), Green Island beach, St. Clair, Lyall Bay: *R. M. L.* St. Clair, North Head (Dunedin): *J. C. S.*

357. *Placophora marchantioides*, J. Ag., Bidr. Alg. Syst., part iv., p. 111. (*Amansia(??) marchantioide*: Fl. Nov.-Zel., p. 223; Anal. Algol., p. 136.)
Cape Kidnappers and Hawke's Bay: *Colenso.*

358. *Vidalia colensoi*, J. Ag., Sp. Alg., p. 1127. (*Epineuron colensoi* : Fl. Nov.-Zel., p. 223.)
East Coast : *Colenso.* Bay of Islands : *Lyall.* Hokianga, Tauranga, Bay of Islands : *Berggren.* Mongonui : *R. M. L.*

359. *Epineuron(?) lineatum.* Fl. Nov.-Zel., p. 223.
New Zealand : *Banks.*
A very doubtful species indeed.

360. *Polyzonia bipartita.* Fl. Nov.-Zel., p. 227. (J. Ag., Alg. N.Z. mar., p. 31.)
Lyall Bay : *R. M. L.* Green Island : *J. C. S.*

361. *Polyzonia incisa*, J. Ag., Sp. Alg., p. 1165. (*Polyzonia harveyana* : Fl. Nov.-Zel., p. 227.)
Almost everywhere common : *R. M. L.* Chatham Islands : *Dr. Schauinsland.*

362. *Polyzonia cuneifolia.* Fl. Nov.-Zel., p. 226.
Stewart Island, Preservation Inlet : *Lyall.* Lyall Bay : *R. M. L.* St. Clair : *J. C. S.*

363. *Polyzonia flabellifera*, J. Ag., Bidr. Alg. Syst., vi., p. 74.
St. Clair : *J. C. S.*

364. *Polyzonia adiantiformis.* Fl. Nov.-Zel., p. 226.
Bluff : *Berggren.*

365. *Polyzonia ovalifolia.* Fl. Nov.-Zel., p. 226. (J. Ag., Florid. Morph., pl. xxii., fig. 23.)
On *Amphiroa corymbosa* : *Colenso.*

366. *Dasyclonium acicarpum*, J. Ag., Anal. Algol., cont. ii., p. 81.
St. Clair : *J. C. S.*
Identified by Agardh.

367. *Lophothalia australis*, J. Ag., Bidr. Alg. Syst., vi., p. 59. (*Polysiphonia australis*, J. Ag., Sp. Alg., p. 1044. *P. cladostephus* : Fl. Nov.-Zel., p. 332.)
Akaroa : *Lyall* ; *Raoul.* Bluff, Lyall Bay : *Berggren* ; *R. M. L.* Maori Kaik, Otago Harbour : *J. C. S.*

368. *Dasya collabens*, Harv., Fl. Nov.-Zel., p. 222.
Akaroa southwards : *Raoul.* Dusky Sound : *J. C. S.*
Identification not certain.

369. *Dasya (Heterosiphonia) firma*, J. Ag., Bidr. Alg. Syst., vi., p. 73.
Paterson's Inlet : *R. M. L.* Chatham Islands : *Travers.*
The identification of my specimens is due to Major Reinbold, and the species is somewhat doubtful.

370. *Dasya squarrosa.* Fl. Nov.-Zel., p. 232. (J. Ag., Bidr. Alg. Syst., vi., p. 83.)
Port William : *Lyall.* St. Clair : *J. C. S.*

A specimen sent to Agardh from St. Clair was considered by him to be either *D. squarrosa* or new.

371. *Dasya (Heterosiphonia) tessellata.* Fl. Nov.-Zel., p. 233. (J. Ag., Bidr. Alg. Syst., vi., p. 86.)

Blind and Massacre Bay: *Lyall.* French Pass: *Dr. Schauinsland.*

372. *Dasya concinna.* (*Rodomela concinna:* Fl. Nov.-Zel., p. 225, pl. iii.) (J. Ag., Alg. N.Z. mar., p. 28; also Anal. Algol., p. 135, footnote.)

Foveaux Strait and Chalky Bay (West Coast): *Lyall.* Bluff: *Berggren.* The Bluff, Brighton (Otago): *R. M. L.* Lyall Bay: (*Reinbold*). Chatham Islands: *Dr. Schauinsland.*

Order **Corallineæ.**

373. *Arthrocardia (Amphiroa) corymbosa.* Fl. Nov.-Zel., p. 237.

East Coast: *Colenso.* Bay of Islands, Chatham Islands: *R. M. L.*

Probably common.

374. *Arthrocardia wardii.* Ner. Austr., p. 99.

Chatham Islands: *Dr. Schauinsland.*

375. *Amphiroa elegans.* Fl. Nov.-Zel., p. 237.

Cape Kidnappers: *Colenso.*

375A. *Corallina armata.* Fl. Nov.-Zel., p. 237.

East Coast: *Colenso.* Lyttelton: *R. M. L.* St. Clair, Brighton: *J. C. S.*

376. *Corallina pedunculata*, Lmx.

Chatham Islands: *Dr. Schauinsland.*

377. *Corallina officinalis.* Fl. Nov.-Zel., p. 237.

Auckland: *Lyall.* East Coast: *Colenso.* St. Clair: *J. C. S.* Lyall Bay, Brighton (Otago): *R. M. L.* Chatham Islands: *Dr. Schauinsland.*

378. *Jania cuvieri.* Fl. Nov.-Zel., p. 237.

Common, Chatham Islands: *Dr. Schauinsland.* Stewart Island, Dunedin: *J. C. S.*

Probably common.

379. *Jania pistillaris.* Fl. Nov.-Zel., p. 237.

Bay of Islands (in holes of rocks): *Hombron.*

Not recently collected.

380. *Jania micrarthodia.* Fl. Nov.-Zel., p. 237.

East Coast: *Colenso.* Port Cooper: *Lyall.* Chatham Islands: *Gisborne.* Ohiro Valley (Wellington): *R. M. L.* St. Clair, Brighton, Stewart Island: *J. C. S.*

381. *Melobesia (Lithophyllum) patena.* Fl. Nov.-Zel., p. 238.
Chatham Islands: *Dr. Schauinsland.*
Probably common.

382. *Melobesia amplexifrons.* Harv., Ner. Austr., p. 110.
New Zealand: *Professor Parker.* Chatham Islands: *Dr. Schauinsland.*

383. *Lithothamnion* sp.? (near *Goniolithon congestum*, Fosl.).
Chatham Islands: *Dr. Schauinsland.*

384. *Lithothamnion calcareum*, Aresch. (*Melobesia calcarea*, Harv., Fl. Nov.-Zel., p. 238.)
Bay of Islands: *Hooker.*

385. *Lithothamnion agariciforme* (Pall.), Fosl., forma(?) *decussata*=*L. decussatum*, Ell. et Sol., not of Solms.
Chatham Islands: *Dr. Schauinsland.*

386. *Lithophyllum carpophylli*, Heydr. *Corallinæ*, in B.D.B., Ges. xi., p. 78.
Chatham Islands, New Zealand: *Dr. Schauinsland.*

Addendum to Part I.* of this Paper.

Order **Codiaceæ.**

387. *Bryopsis plumosa.* (*B. plumosa*: Fl. Nov.-Zel., p. 261, *partim(?).*) J. Ag., Bidr. Alg. Syst., v., p. 24.
New Zealand: *(Agardh).*

11. *Codium mucronatum*, J. Ag., Bidr. Alg. Syst., v., p. 43.
This replaces, possibly entirely, *C. tomentosum* (Fl. Nov.-Zel., p. 261) of the first part of this list.

388. *Codium muelleri*, J. Ag., Bidr. Alg. Syst., v., p. 42.
Chatham Islands: *(Travers).*

Order **Ulvaceæ.**

389. *Porphyra subtumens*, J. Ag. (*Mscr.*).
A small species of *Porphyra* grows very commonly on *D'Urvillæa*, and on forwarding specimens to Agardh he named it as above; but I have not seen any published description of it, and am unaware if there is one.
Akatore (on *D'Urvillæa*): *R. M. L.*

Order **Dictyotaceæ.**

70. *Dictyota ocellata.* Anal. Algol., cont. i., p. 68.
This species replaces *D. dichotoma* of the first part of this list.

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* Trans. N.Z. Inst., vol. xxxii., p. 57.

REFERENCES.

The following are the chief references additional to those given in the first part of this paper. The references to the "Flora Novæ-Zelandiæ" are all to volume ii.

1. "Species Algarum," 1848–63. (J. Agardh.)
2. "Bidrage till Algernes Systematik," parts iv., v., vi. Lunds Univ. Årsskr., tom. xxi. and xxiii. (J. Agardh.)
3. "Epicrisis Floridearum," 1876. (J. Agardh.)
4. "Analecta Algologica,"* 1892–99. (J. Agardh.)
5. "De dispositione Delesseriearum," 1898. (J. Agardh.)
6. "Flora Antarctica," 1847. (Sir J. D. Hooker.)

The species of the order *Sphacelariaceæ* are being revised in the "Journal de Botanique" by Professor Sauvageau (August, 1900, *et seq.*). Already several New Zealand forms have been dealt with. De Toni's "Sylloge Algarum," unfortunately, is not procurable in the colonies, but would be of considerable assistance to the student.

I cannot close this paper without referring to the death, at a ripe old age, of the greatest of algologists, Professor J. G. Agardh. I found him always ready and willing to assist me, and I regret that he was unable himself to draw up this list, when it would have been of much greater value than it is.

ART. XXXI.—*On the Occurrence of* Panax arboreum *as an Epiphyte on the Stems of Tree Ferns in the Mauku District.*

By H. CARSE.

[*Read before the Auckland Institute, 7th October, 1901.*]

IN a paper read before the Hawke's Bay Philosophical Institute on the 9th August, 1886, by the late Mr. Colenso, mention is made† of the peculiar growth of a *Panax arboreum* upon and around the stem of a tree fern, *Cyathea dealbata.* Mr. Colenso said, "I have a curious anomaly to mention, which, as far as I know, is quite unique. Four years ago, while botanising in the high and dry woods near Matamau, I came upon a fine tree fern (*Cyathea dealbata*) whose caudex

* I have, unfortunately, not seen the sixth part of this work.—R. M. L.

† Trans. N.Z. Inst., vol. xix., p. 257.

below was almost wholly surrounded by its former epiphytal foster-child, a stout spreading specimen of *Panax arborea*, from which or out of which the fern-tree luxuriously grew as if it were springing from a large vase. On the one side (or, rather, speaking correctly, on three sides) the tree fern was wholly enclosed."

I am not aware whether any other botanist since Mr. Colenso's time has drawn attention to this peculiar habit of growth of *Panax arboreum*, or whether it is of frequent occurrence, but I have noticed so many examples of this curious combination that I thought it might prove of some interest once more to draw the attention of the students of plant-life of our country to this subject.

For some reason which I am unable to explain *Panax arboreum* is almost invariably an epiphyte on the stems of tree ferns in the forest regions around Mauku. In open *Leptospermum* scrub, on banks of streams, and on declivities, when tree ferns are not present, *Panax* grows as a standard. As an epiphyte *Panax arboreum* may be seen as a seedling a few inches high, as a sapling a few feet high, or as a tree 20 ft. high. The roots of the seedling appear to strike inwards among the damp fibrous remains of old stipes until, reaching the hard inner coating of the caudex, their further inward progress is barred. One root, which I take to be the tap-root, now begins to make its way earthwards, usually in a more or less straight line, though occasionally they appear to progress spirally. As the young tree increases in stature other roots are given off from the original base of the *Panax*—*i.e.*, from the point on the trunk of the tree fern where the seed germinated. In some cases these roots follow the line of the first; in others they appear to grow for a time laterally before descending. With increased growth of the tree the roots become so crowded together that they grow one into another and coalesce, forming a continuous mass of what for want of a better name I have called "root-stems," for by this time they have ceased to be roots, and true roots are now developed in the soil round the base of the fern-tree. While the "root-stems" have been growing downwards the upper stem has ascended, in some cases in line with the fern-tree, in others at a greater or less angle with the caudex. In some cases the "root-stems" have entirely enveloped the caudex of the fern-tree for 5 ft. or 6 ft. above the ground, and have grown so closely together as to present the appearance of a solid *Panax* trunk, thus giving the appearance of a growing from an urn, referred to by Mr. Colenso. In other fern-tree cases they have formed a more or less open network, through the meshes of which the caudex of the fern-tree is visible.

In some of the specimens I noticed the tree fern was perfectly healthy and in a robust state; in others it was apparently suffering from the close embraces of its too vigorous foster-child, as was shown by the poorly developed fronds. In two cases I saw the enclosed tree ferns had succumbed. In one of these instances the lower part of the caudex was entirely surrounded by the coalescing "root-stems" of the *Panax*, except at one point, where about 6 in. of the caudex was visible. Rising above the point where I judged the germination of the *Panax* to have taken place was seen about 2 ft. of caudex half imbedded in the trunk of the *Panax*. What remained of the caudex was dry and brittle, having apparently been dead for many years. Judging from the remains, I concluded that it had been a *Dicksonia squarrosa*, which fern is plentiful in the immediate vicinity. In the second case the circumstances are very similar, save that the enveloping and fatal "root-stems" have formed a ring about 3 ft. above the ground and have then coalesced, forming a concave trunk containing the compressed remains of the fern, apparently also a *Dicksonia*. In these two cases no "Crowner's quest" appears necessary as to the cause of death. The self-evident verdict must be "Death from constriction." But in another case further inquiry is called for. The facts are as follow: A *Panax arboreum* has germinated on a *Cyathea dealbata*, has grown and flourished until it became a tree 20 ft. high, its coalescing "root-stems" enveloping a considerable portion of the stem of its foster-parent. The strange thing in this case is that, while the tree fern is in a state of luxuriant growth, producing a fine crown of fronds, the *Panax* is dead and dry.

From my observations I have arrived at the conclusion that *Cyathea dealbata* probably in many cases suffers in health from the embraces of *Panax arboreum*, but rarely, if ever, succumbs; but that *Dicksonia squarrosa*, being usually less robust, is more apt to find these embraces fatal.

Whether this peculiar habit of *Panax arboreum* shows its natural affinity with the ivy-plant (*Hedera*), as suggested by Mr. Colenso, or no, I leave to more advanced students of nature to decide; but it seems to me we might say the same of the rata (*Metrosideros robusta*), which usually begins life as an epiphyte in the clefts of the upper branches of forest trees, and frequently serves its foster-parent in a manner similar to that described above in the case of *Dicksonia squarrosa*.

Subjoined are a few notes of measurements in some of the cases referred to:—

No. 1. *Cyathea dealbata*, 15 ft. high; *Panax arboreum*, 20 ft. high. Point of germination, 6 ft. above ground.

Caudex entirely enveloped 4 ft. upwards from ground. *Cyathea* unhealthy.

No. 2. *Cyathea dealbata*, 10 ft. high; *Panax arboreum*, 15 ft. high. Point of germination, 8 ft. above ground. Single "root-stem" descending spirally.

No. 3. *Dicksonia squarrosa* (?); *Panax*, 20 ft. high. Germinating-point, 6 ft. above ground. Crushed remains of dead fern show near ground, and again 7 ft. up.

No. 4. *Dicksonia squarrosa* (?); *Panax*, 15 ft. high. Point of germination, 4 ft. up. Crushed remains of dead fern show on opposite sides of coalescing "root-stems," 2 ft. and 5 ft. up.

Art. XXXII.—*On the Flora of the Mauku District.*

By H. Carse.

[Read before the Auckland Institute, 2nd September, 1901.]

"All rivers flow to the sea," and every stream helps to swell the volume of some river. I am sending forth the little creeklet of my observations to help to swell the great river of botanical knowledge, which is constantly bearing useful information and pleasure to thousands of true lovers of nature.

These notes are the outcome of a suggestion that the observations on botanical subjects by a resident in a particular district may be of some use to botany generally, in that they afford opportunities of comparing the flora of one district with that of others in the same country. This suggestion was made to me at one time by Mr. Cheeseman, and again by Mr. Petrie. I am glad to avail myself of this opportunity to tender to these gentlemen my hearty thanks for the great encouragement, ready assistance, and valuable information I have received from them from time to time during the period —a few years only—in which I have devoted my spare time to the fascinating study of plant-life.

The region to which my notes refer is that part of the Manukau County which is bounded on the north by the Manukau Harbour, on the east by the railway-line, on the south by the Waikato River, and on the west by the Tasman Sea. The Settlement of Mauku is fairly central, and was my headquarters. When first I arrived in the district, two years ago, I was afraid that as a field for botanical research it would prove very poor. But longer acquaintance with it

has shown it to be not, indeed, a rich district botanically, but certainly much better than I had at first anticipated.

My neighbour, Mr. Heywood Crispe, who has lived here all his life, and who served against the Maoris in the war-time, tells me that in his younger days all the land round here, where now fertile soil and prolific crops repay the settlers' toil, was covered by dense primitive forest. Indeed, that such was the case is even now evident from the stumps and roots of old monarchs of the glade remaining here and there. Small isolated patches of bush, many of them of second growth, and these rapidly disappearing before axe and fire, are all that are now left of the great forest which a few decades since covered a vast tract of country.

The most fertile part of this region, which was in consequence of that fertility the first to be settled, was acquired by confiscation from the natives for their share in the war. It consists mainly of a more or less undulatory tableland, stretching from Pukekohe nearly to Waiuku. The average height of this tableland is, I believe, about 300 ft. above sea-level, and rising from it are two points of higher elevation —viz., Pukekohe Hill, near the village of Pukekohe, and the Bald Hills, near Mauku. These hills rise to a height of about 700 ft. above sea-level. Towards the north the area above referred to sinks more or less gradually to the level of the Karaka Flat; on the south it is bounded by the lands sloping down to the Waikato River and the Ake-ake Swamp, the latter being little above sea-level; on the west lies the Waiuku arm of the Manukau Harbour, beyond which the country is more or less broken and rises towards the sand-hills which lie parallel to the coast from the Manukau to the Waikato Heads. It is in this stretch of country that most of what remains of bush is to be found.

The Karaka Flat is an undulating stretch of country extending from near Drury almost to Waiuku, and lying between the area above referred to and the Manukau Harbour. It is intersected by the Mauku arm of the Manukau Harbour, the Waiau arm, and other smaller openings. This part of the district is somewhat dreary in appearance, the vegetation as a rule being low and stunted, except in a few spots more sheltered than the general run of the surrounding land. In fact, were it not for the frequent clumps of introduced shelter-trees surrounding the houses of settlers here and there the scene would be very monotonous.

One thing that has struck me as remarkable in this district is the absence of certain plants which, in most parts of the country, both north and south of Auckland City, are more or less common. Nowhere along any of the creek-banks—not even along the Waikato—have I seen *Plagianthus*

betulinus or *Hoheria populnea*, though I understand they occur about Tuakau, a district I have not yet been able to include in my notes. *Weinmannia sylvicola*, so plentiful in many districts, is here conspicuous by its absence. In vain have I explored the Karaka Flat, a most likely country, for *Dracophyllum urvilleanum* and *D. squarrosum*. Nor have I yet seen a single plant of *Rhabdothamnus solandri* in the district; and the same thing is noticeable of many other plants. On the other hand, several plants occur in this region, more or less plentifully, of which I have seen few or none in other places I have visited. *Melicytus micranthus* var. *longiusculus* occurs very sparingly. *Hydrocotyle dissecta*, which according to the late Mr. Kirk is "a remarkably rare and local lowland species," is here very plentiful in almost every piece of bush. Recently I discovered an unusually large form of this species, of which Mr. Cheeseman says, "I have never seen *Hydrocotyle dissecta* so large as the specimen you send." The graceful little plant *Gratiola nana* is not uncommon in the swampy parts of the Karaka Flat. Here also *Utricularia novæ-zelandiæ*, *U. colensoi*, and *Drosera spathulata* occur freely. So far I have looked in vain for *D. pygmæum*. *Prasophyllum colensoi* is very rare in the district; in fact, I have only found one plant of this beautiful and interesting orchid. The recently named *Schœnus carsei* occurs sparingly in two localities. *Bulbophyllum tuberculatum*, another very interesting orchid, originally discovered in the Hawke's Bay District by Mr. Colenso in 1883, is plentiful on the upper branches of trees in the swampy bush bordering the Waikato River. I understand that this plant was not seen after its discovery by Colenso until rather more than a year ago, when it was rediscovered almost simultaneously by my friend Mr. R. H. Matthews at Kaitaia, in the Mongonui County, and by myself in this district. Mr. Petrie's *Hydrocotyle hydrophila* is not uncommon, and *Myosotis spathulata* and *Pterostylis graminea* occur sparingly.

Of ferns and allied plants, *Hemitelia smithii* (two plants only), *Lindsaya viridis*, *Nephrodium thelypteris*, and *Marattia fraxinea*, the edible para of the natives, are of considerable interest. But certainly the most interesting plant in this class is *Lycopodium scariosum*, which occurs on a clayey bank at only a few feet above sea-level. I understand this species rarely occurs below an elevation of 1,000 ft. in the north of New Zealand.

In what remains of forest the trees of most frequent occurrence are *Beilschmiedia tawa*, *B. tarairi*, *Dysoxylum spectabile*, *Pittosporum tenuifolium*, *P. eugenioides*, *Hedycaria dentata*, *Vitex littoralis*, &c. Of those less plentiful, but still frequently observed, may be mentioned *Knightia excelsa*,

Metrosideros robusta, *Coprosma arborea*, *Panax arboreum*, *Olearia cunninghamii*, *Olea lanceolata*, &c. Many of the forest trees are festooned by such vines and climbing-plants as *Metrosideros florida* (whose gorgeous scarlet flowers lend colour to the bush from February to May), *M. scandens*, *M. hypericifolia*, *Parsonsia albiflora* and *P. rosea*, the supple-jack vine (*Rhipogonum scandens*), the bush-lawyer (*Rubus*), and *Passiflora tetrandra*, which grows with great luxuriance in this district.

The undergrowth consists mainly in many places of *Coprosma areolata* intermixed with other *Coprosmas*, *Melicope simplex*, *Melicytus micranthus*, *Myrtus bullata*, *Geniostoma ligustrifolia*, and *Pennantia corymbosa*.

Of plants growing as epiphytes those most frequently met with are various species of *Astelia*, among which grow *Pittosporum cornifolium* and the beautiful *Senecio kirkii*, with its large daisy-like flowers. *Griselinia lucida*, with its large shining leaves, is a conspicuous feature on many of the forest trees. The trunks and branches of the trees are more or less clothed with a luxuriant growth of smaller orchids, ferns, lycopods, and mosses.

In many places in the more shady parts of the bush the ground is fairly carpeted with *Hydrocotyle dissecta*, *Galium umbrosum*, *Dichondra repens*, *Corysanthes macrantha*, *C. triloba*, *Oplismenus undulatifolius*, and other plants. *Pterostylis banksii* is plentiful, *P. trullifolia* not uncommon, while *P. graminea* is rare. The lower parts of the trunks of trees and rocks are frequently clothed with a luxuriant growth of *Peperomia endlicheri*. *Acianthus sinclairii* is fairly plentiful, and in damp spots *Corysanthes oblonga* and *Chiloglottis cornuta* are frequently met with.

Among *Leptospermum* scrub, near the edge of the bush, *Clematis indivisa*, the only species of this genus I have found in the district, is not uncommon. Here also are to be found *Gaultheria antipoda*, *Luzula campestris*, *Caladenia minor*, *Lycopodium volubile*, *L. densum*, and only one solitary specimen of the usually plentiful *Adiantum hispidulum*, while *A. æthiopicum* and *A. affine* are not uncommon.

In nearly every piece of bush *Lomaria discolor* is plentifully distributed, and the graceful *Pteris macilenta* is a conspicuous feature. Large masses of the beautifully slender *Hypolepis distans* are of frequent occurrence.

The Bald Hills are well worth a visit. They consist of a group of several rounded hills within a couple of miles of Mauku. The summits of these hills are almost bare of vegetation, save a slight growth of native and introduced grasses, with here and there clumps of *Pteris*. Approaching the Bald Hills from the Mauku–Waiuku Road we first pass Titi Hill,

famous as the scene of an encounter between the Forest Rangers and the Maoris during the war, when the old church of St. Bride was utilised as a stockade.

Ascending the first hill, we follow a track through a piece of bush in which the more interesting plants are *Melicope ternata* and its variety *mantellii*, *Gahnia lacera*, *Uncinia banksii*, *Pterostylis trullifolia*, *Bulbophyllum turberculatum*, *Botrychium ternatum*, and *Piper excelsum*. Passing on through *Leptospermum* scrub, we enter the remains of an old pa, and so to the summit of the highest hill. From this point a splendid view is obtainable all around. Not far from the Trig. station on the summit is a small patch of *Luzula campestris*. Towards the west there are several small gullies which furrow that side of the hill. In one of these are two plants of *Entelea arborescens*, the only ones I have yet seen in the district. Mr. Cheeseman, however, informs me that it is found in the sandhills between Waiuku and Manukau, a part of the district I have not yet had time to explore.

In several places on this and the other hills are outcrops of sandstone, usually of a more or less rounded appearance, as though (as probably was the case) they had at some distant date formed bluffs on the bank of some river, or, perhaps, sea-shore. In a dry spot at the base of one of these bluffs I found a stunted form of *Carex inversa*, a plant not at all common in the district. Here and there, in crevices of the rocks or among the scrub which clothes a greater part of the north and west sides of this hill, are to be noted plants of *Doodia media* and *Aspidium richardii*, neither of which are at all well represented in this neighbourhood. In many of the larger gullies separating the Bald Hills there are still considerable patches of bush. In the upper part of one of these, where the soil is light and dry, I found the finest specimens of *Asplenium hookerianum* I have yet seen. In the lower part of another, through which flows a small stream, in the deep shade of the forest, are some fine specimens of *Marattia fraxinea*, now becoming so rare in our Island. On many damp clay banks, on the edge of or near to the creek, are many hundreds of seedling plants. In this same bush *Coprosma spathulata* occurs freely, and here I discovered one plant with crimson drupes, a rather unusual occurrence. Higher up and near the edge of the bush *Carex vacillans* is not uncommon, and among scrub just outside the bush are a few plants of *Dodonæa viscosa*.

Ascending this hill from the bush we come to a large pa on its summit, passing, in the more open parts, *Rumex flexuosus*, *Scirpus nodosus*, and here and there *Olearia solandri*. The two last are usually maritime plants. This hill overlooks the Lower Waikato and the Ake-ake Swamp.

The southern face is an abrupt descent, from which sandstone rock crops out in several places. In some places this rock is covered with a growth of *Metrosideros diffusa*, one of the handsomest plants of the genus. On the drier parts of the hills *Carex breviculmis* is of frequent occurrence.

The Mauku Creek and its banks are not without botanical interest. This creek rises beyond Puni, and, flowing for the greater part of its way through a fairly level valley, has in that part a very slight fall. In the deeper parts of the creek *Myriophyllum robustum* is plentiful. This handsome plant roots in the muddy bottom; its stems, long or short according to the depth of the water, slope diagonally with the current. In early summer the new growths are produced. These emerge from the water like miniature pine-trees, and produce flowers and fruit in the axils of the leaves. In a small coppice on the bank of the creek, in land subject to inundation, occur a few plants of *Myosotis spathulata*, the only specimens I have seen in this region. Lower down in a shady wood *Adiantum diaphanum* is not uncommon. Here also, among *Cordyline australis*, are to be found *Melicytus micranthus*, *Paratrophis microphyllus*, and various species of *Coprosma*. All along the banks and in the swampy land bordering the creek occur *Phormium tenax*, *Sparganium simplex*, *Cladium teretifolium*, *Carex pseudocyperus*, and other water-loving plants; and in one swampy feeder of the creek the graceful grass *Hierochloe redolens* is found.

In Mauku the creek is dammed up to work Mr. Notts's flax-mill. In the mill-dam among other plants *Cladium articulatum* is plentiful. About a mile lower down, the stream falls abruptly over rocks of basaltic formation into a ravine 45 ft. below the surrounding country. The most interesting plants on the wet rocks below the fall are *Nertera cunninghamii* (the only place where I have seen this species about here), *Mentha cunninghamii*, *Pratia angulata*, *Corysanthes macrantha*, *Gnaphalium collinum*, and *Adiantum affine*. Among the loose rocks which cover the greater part of the ravine grow *Brachyglottis repanda*, *Melicytus ramiflorus*, *Metrosideros diffusa*, *Schefflera digitata*, *Myrsine salicina*, &c.; and on the rocks and in their crevices *Peperomia endlicheri*, *Polypodium billardieri*, *P. cunninghamii*, *Hymenophyllum javanicum*, *Trichomanes humile*, and *Asplenium bulbiferum* are more or less plentiful. In the upper and drier parts of the ravine are to be found *Asplenium hookerianum*, *A. bulbiferum* var. *tripinnatum*, and *Astelia cunninghamii*.

About a couple of miles lower down we reach the highest point affected by the tide, which comes up the Mauku arm of the Manukau. On the muddy flats occur *Scirpus lacustris*, *S. maritimus*, *Juncus maritimus*, *Cladium junceum*, *Carex*

littorosa, *Leptocarpus simplex*, *Selliera radicans*, *Apium filiforme*, and *Plagianthus divaricatus*. On the clay banks of the creek, and extending a considerable distance inland, *Olearia furfuracea* is very plentiful. On the clay bank also a few plants of *Veronica macrocarpa* are to be found.

Lower down the creek, where the channel at high water is about a quarter of a mile wide, is a favourite picnic spot known as "The Bluff." Here cliffs formed of clay rise 40 ft. or 50 ft. above the level of the water. A few interesting plants are to be noted here—viz., *Ranunculus acaulis*, *Samolus repens*, *Veronica macrocarpa*. Here, too, I found two lycopods which I have not seen elsewhere in this district. One of these is *Lycopodium cernuum*, the other *L. scariosum*. The latter, as before noted, has not previously been reported in north New Zealand at an elevation of less than 1,000 ft.

Still lower down a branch creek strikes off at right angles. Here on a high sloping bank are several interesting plants, the most interesting being a small kauri-tree about 20 ft. high, bearing, when I first visited the spot, well-developed cones. This is certainly a most unexpected spot to find a kauri-tree, for at present, unless I am much mistaken, there is not another tree of this species within ten miles. Long, long ago, no doubt, kauris were plentiful here, as a considerable amount of gum has been dug in the immediate neighbourhood. Is it possible that this small tree is a descendant of its prehistoric ancestors which grew on the surrounding Karaka Flat? If not, how did the seed get to this out-of-the-way spot? At the foot of this interesting tree is a clump of *Phebalium nudum*, and under that again a large patch of *Gleichenia cunninghamii*, the only specimens I have yet seen in this district. Here, also, *Coprosma lucida* is not uncommon.

Leaving the water-side, we now strike across the Karaka Flat. Frequent fires have destroyed much of the vegetation. Low *Leptospermum* scrub covers vast areas, except where a few enterprising settlers are rapidly clearing and ploughing. Here and there, on the edges of small gullies and upon hillocks, the monotony of the scene is broken by the presence of *Olearia furfuracea*, *O. solandri*, *Leucopogon fasciculatus*, *Cassinia retorta*, and *Cyathodes acerosa*. Among the low scrub such plants as *Schœnus tend›*, *Lepidosperma concava*, *L. australis*, *Leucopogon fraseri*, *Epacris pauciflora*, and *Pomaderris phylicifolia* are of common occurrence. *Haloragis tetragyna*, the typical plant, is not uncommon in more or less open spots, and its variety *diffusa* is everywhere abundant. Large areas, too, are covered with the long trailing stems and graceful fronds of *Lycopodium volubile*. In many places,

especially in the more open parts, *Thelymitra longifolia* is especially plentiful, and here and there *Prasophyllum pumilum* is to be found.

In the frequently occurring swampy patches the most interesting plants are *Drosera spathulata*, *D. binata*, *Utricularia colensoi*, *U. novæ-zelandiæ*, *Gratiola peruviana*, *G. nana*, *Thelymitra pulchella*, *Cladium capillaceum*, *Schœnus tenax*, and *S. carsei*.

In some parts of the Karaka Flat *Epacris purpurascens* grows freely, and I am informed by Mr. A. T. Urquhart, of Karaka, that this species occurs on his land associated with *E. microphylla* and *E. pulchella*. How these Australian species have become naturalised in this district, and as far as I am aware nowhere else in New Zealand, is, I believe, an unsolved problem. It has been suggested that they may be indigenous, but, seeing how remarkably local they are, this seems hardly probable.

At the mouths of some of the tidal creeks opening into the Manukau Harbour the mangrove, *Avicennia officinalis*, occurs, and here and there are a few trees of *Metrosideros tomentosa*. On the bank of a small stream flowing into the Waiau Creek I found, among *Leptospermum* scrub, *Caladenia minor*, *Cotula minor*, *Hydrocotyle moschata* (a dwarf form), and fine specimens of *Botrychium ternatum*.

Another favourite picnic spot is Waitangi, near Waiuku. A small creek is here dammed up to drive the wheel of the Waitangi flour-mill; it then enters the Waiuku arm of the Manukau. Among the more interesting plants growing here may be mentioned *Sophora tetraptera*, which is by no means common in this district, *Dodonæa viscosa*, *Cyathodes acerosa*, *Veronica macrocarpa*, *Corokia buddleoides*, *Phebalium nudum* and *Cladium sinclairii* growing along the cliffs. On a sandy flat I also noted *Ranunculus acaulis* and *Suæda maritima*, and in one spot, among *Leptospermum* scrub, I found one plant of *Epilobium alsinoides*, a rare plant in this neighbourhood. Near here also occur a few small ngaio-trees (*Myoporum lætum*), a species by no means plentiful in this region.

A favourite excursion of mine is to the west coast. The distance is about eleven miles, and the route lies through the village of Waiuku. A noticeable feature along many parts of the road between Mauku and Waiuku is the great number of young totara-trees. This tree seems to thrive better in the open than almost any other native tree. Not far from the Waitangi School one can hardly fail to notice, in the flowering season, two plants of *Metrosideros florida* with yellow stamens growing on the edge of a small piece of bush. This form of the species is the late Mr. Kirk's "variety

aurata." In his "Students' Flora" Mr. Kirk mentions three localities only in which this form has been observed, and states that only one specimen has been seen at each of the places he names, none of which are in the Auckland District. I am of opinion that this form, while not common, is by no means as rare as has been supposed, for I know of two plants at Maungatapere, near Whangarei, and four plants in this district. Near Mauku, too, a form with orange-red stamens is not uncommon.

By making a short detour from the road we can visit a piece of bush on Mr. West's land, in which a few trees of *Libocedrus doniana* and *Phyllocladus trichomanoides* are to be seen. Neither of these species are at all common. In another part of this bush are a few plants of *Marattia fraxinea.*

Skirting the village of Waiuku, we come on to the Kariotah Road, which leads to the coast, and after about two miles on an easy grade the road begins to ascend. Just before reaching the first of the sandhills there is a small pond on the roadside, dry in summer. In this I found the somewhat rare grass *Amphibromus.* This has been figured and described by the late Mr. Kirk as a new species, but I understand there are doubts as to whether it is not the Australian species, *A. neesiana.* Judging from his figures, the specimens Mr. Kirk obtained in the Waikato lakes were very poor compared with those I got in this little wayside pond.

From this spot a few minutes' ride brings us to the first of the sandhills. On the right is a clear and apparently deep lagoon covering an area of 5 or 6 acres. This lakelet has been formed by the ever-advancing sand damming up a small creek, whose waters now percolate through about a quarter of a mile of sand and come out in a deep ravine, through which the creek flows down to the beach.

We now enter the Kariotahi Gap. These "gaps," of which there are several between the Manukau and Waikato Heads, are the only means of access to the beach. Through each of these flows a small creek, which probably assists in some measure in keeping these passes open. When well in the gap the scenery, to my mind, is suggestive of a desert. The sand is generally of a dark hue, owing to the presence of considerable quantities of ironsand. The monotony of the scene is broken by a view of the ocean at the lower end of the gap, and by a few arenaceous plants, such as *Coprosma acerosa, Scirpus frondosus,* and *Arundo conspicua,* the latter being always a most conspicuous plant on sand-dunes and in inland swamps. In a swampy place at the edge of the gap I found *Mentha cunninghamii, Epilobium billardierianum, Haloragis depressa,* and *Juncus cæspititius.* The lower part of the

gap narrows to a mere track, which reaches the beach at the mouth of the creek above mentioned. Here a grassy flat affords a good place to allow our horses to have a rest and feed before proceeding along the beach, and good water and an abundant supply of watercress suggest the advisability of boiling the "billy" for lunch.

I regret that I have not been able to devote as much time as I could wish to this interesting part of the district; but, still, I have explored to some extent. On the drier parts of the cliffs, and not unfrequently on blown sand, *Mesembryanthemum australe* is plentiful. Where water drips I noted *Sonchus asper* var. *littoralis* in great abundance, and here and there *Cotula dioica* occurs. Such plants as *Apium australe*, *Samolus repens*, *Selliera radicans*, *Lobelia anceps*, and *Triglochin triandrum* are abundant. In wet sand, usually at the tops of the cliffs, are large matted patches of *Gunnera arenaria*. In drier sandy spots *Coprosma acerosa*, *Linum monogynum*, *Tillæa sieberiana*, *Muhlenbeckia complexa*, *Cassinia retorta*, *Zoysia pungens*, and *Senecio lautus* are common, as also are *Pimelea arenaria* and *P. lævigata*. In rather damp places between the cliffs and the beach stunted forms of *Corynocarpus lævigata* are of frequent occurrence, intermixed with *Pseudopanax lessonii*, *Coprosma baueriana*, and often as an undergrowth large patches of *Pteris comans*. In some places *Tetragonia trigyna* climbs 6 ft. or 7 ft. up the shrubs, and *T. expansa* is often met with. *Parietaria debilis* also occurs in shady places. In sandy spots *Carex pumila*, *C. testacea*, and *Spinifex hirsutus* are of frequent occurrence. In a few damp spots I noted *Poa australis* var. *lævis*, and on the low cliffs the beautiful renga lily (*Arthropodium cirrhatum*) is of frquent occurrence.

I have ridden along the splendidly smooth beach as far as the Manukau Heads, but as it was in the teeth of a howling nor'-wester, accompanied by heavy rain, I was unable to do much botanically. I noted a large group of pohutukawas with straight trunks, very unlike the usual gnarled and twisted forms so familiar all along the coast. I understand from Mr. Petrie that *Myriophyllum pedunculatum* and *Discaria toumatou* occur among sandhills near Waikato Head, but I have not yet been able to look up that part of the coast.

Another very interesting botanical excursion is to the Lower Waikato. This is about seven miles from Mauku. A considerable part of the way lies along what is known as "The Tram." Before the railwaywas formed it was proposed to connect the Waikato district with Auckland by means of a tramway joining the Manukau to the Waikato River. Goods were to be sent from Onehunga up the Mauku branch

or arm of the Manukau, thence by tram to the river somewhere near Cameron Town. The road was formed for over three miles, and is still 2 chains wide, one side being intended for the tramway and the other for ordinary traffic. The formation of the railway, however, knocked this scheme on the head. Much of the tram between Mauku and Puni passes through low-lying swampy land from which a good deal of gum has been dug. On either side of the road is high *Leptospermum* scrub, among which grow *Panax arboreum*, *Quintinia serrata*, *Carpoditus serratus*, &c. In a swamp on the edge of the road I found one specimen of the beautiful orchid *Prasophyllum colensoi*, the only one I have seen so far in the whole district.

Turning down by the Puni School and up a long hill we reach Mr. Shipherd's house, from which a magnificent view of the Lower Waikato is to be obtained. The river is seen, studded with numerous small islands, winding about through the low-lying land which stretches for miles in places on either side. Much of this level land is covered with dense kahikatea forest. In the bush near Mr. Shipherd's is one plant of *Pteris comans*. This is the only plant of this species I have ever seen so far from the sea.

A ride of about two miles brings us to the bank of the river at the site of an old flax-mill. In this part of the river in some places there is a high bank close on the water's edge, while in others is a stretch of swampy land from a few yards to a mile or more in breadth, frequently covered with kahikatea bush, or, where it is open, with *Typha angustifolia* and other swamp plants. These swamps are, as a rule, negotiable in the summer, but are very awkward places to get into, and much more so to get out of again, owing to the great height of the raupo and sedges. In and on the margin of the water (for the river is affected by the tides) the more interesting plants are *Potamogeton ochreatum*, *P. cheesemanii*, *Myriophyllum variæfolium*, *M. elatinoides*, *Limosella aquatica*, and a curious dwarfed form of *Pratia angulata*. Mr. Petrie's *Hydrocotyle hydrophila* is also fairly plentiful. In muddy spots *Elatine americana* and *Callitriche muelleri* are of frequent occurrence. In drier spots the typical form of *Pratia angulata*, *Hydrocotyle novæ-zelandiæ*, and *Ophioglossum vulgatum* occur. Floating on wet swamps are *Lemna minor* and *Azolla rubra*. In most of the swamps such plants as *Scirpus maritimus*, *Carex ternaria*, and *C. subdola* are plentiful. In land more or less submerged *Mazus pumilio* and *Viola lyallii* occur; and here also I found a few plants of *Nephrodium thelypteris*. In a warm sheltered spot I noted a few plants of *Asplenium umbrosum*, a fern somewhat rare in this district.

Perhaps the most interesting plant in the Lower Waikato, or, in fact, in any part of the district, is the dainty little orchid *Bulbophyllum tuberculatum*. In December, 1900, I discovered large quantities of it in the upper branches of trees that had been felled. It was then in fruit, having flowered evidently in November. While I write — May, 1901 — I have this species flowering on an apple-tree. Probably it flowers right through the warm season, and even into the winter. Unfortunately, the plants I discovered in 1900 have all been destroyed in the burning of the felled trees, but I think it is probable that the species is plentiful in the upper branches of trees all along the river-side.

In the swampy bush, which consists chiefly of *Podocarpus dacrydioides*, *Coprosma rotundifolia* is not uncommon, and other *Coprosmas* are plentiful. Here I found a kauri-tree, its roots being in water nearly all the year round. A few other trees of this species grow on a dry bank not far away. Along the river-bank is the only place in the district where I have seen *Calystegia tuguriorum*, and here also I found *Bidens pilosa* quite 6 ft. high, and *Potentilla anserina*. *Ranunculus macropus* is common, but owing to its being so frequently submerged does not flower. *Carex dipsacea* is plentiful along the river-side, and here too I found one solitary plant of *C. inversa*.

While speaking of the genus *Carex*, I would like to refer to a somewhat peculiar form of *C. lucida* which is not uncommon in the Lower Waikato region and in Mauku. This form has compound ♂ spikelets, a rather unusual state, but not so uncommon as was at one time thought. This species frequently has the culms much elongated in fruit. I carefully measured the culms of a specimen recently, and found it had attained the unusual length of 7 ft. 4½ in.

And now I must draw my notes to an end. I have, on paper, revisited many of the scenes of interesting botanical discoveries, and trust that these notes may be of some use botanically.

In the subjoined list will be found the names of 405 flowering-plants and ferns observed in this district. The 405 species represent seventy-eight natural orders. The largest orders are *Filices*, with seventy-one species; *Cyperaceæ*, forty-four species; *Orchideæ*, twenty-two; *Compositæ*, twenty-one; *Rubiaceæ*, eighteen; and *Gramineæ*, seventeen. The largest genera are *Coprosma* and *Carex*, with fourteen species each; *Hymenophyllum*, with ten species; *Epilobium* and *Polypodium*, with eight species each; and *Scirpus*, *Cladium*, and *Lomaria*, with seven species each.

Catalogue of the Flowering-plants and Ferns observed in the Mauku District.

Ranunculaceæ.

Clematis indivisa, *Willd.* Mauku; Bald Hills; Lower Waikato.
Ranunculus hirtus, *Banks and Sol.* General.
" plebeius, *R. Br.* General.
" rivularis, *Banks and Sol.* Not uncommon in wet places.
" acaulis, *Banks and Sol.* Moist sandy shores.
" macropus, *Hook. f.* Wet swamps, Lower Waikato.

Cruciferæ.

Nasturtium palustre, *DC.* Not uncommon in wet places.
Cardamine hirsuta, *L.* In damp places; common.

Violarieæ.

Viola lyallii, *Hook. f.* Swampy places, Lower Waikato.
Melicytus ramiflorus, *Forst.* In woods; common.
Melicytus micranthus, *Hook. f.* Var. *microphyllus*: Common. Var. *longiusculus*: Not common, Mauku.

Pittosporeæ.

Pittosporum tenuifolium, *Gærtn.* Common in woods.
" cornifolium, *A. Cunn.* Common in woods.
" eugenioides, *A. Cunn.* Not uncommon in woods.

Caryophylleæ.

Stellaria parviflora, *Banks and Sol.* Plentiful in shady places.

Elatineæ.

Elatine americana, *Arnott.* Wet places, Lower Waikato.

Hypericineæ.

Hypericum japonicum, *Thunb.* Not uncommon in wet places.

Malvaceæ.

Plagianthus divaricatus, *Forst.* Plentiful along tidal creeks.

Tiliaceæ.

Entelea arborescens, *R. Br.* Bald Hills; rare. Between Waiuku and Manukau Heads: *Cheeseman.*
Aristotelia racemosa, *Hook. f.* Generally distributed.
Elæocarpus dentatus, *Vahl.* Not uncommon in woods.

Lineæ.

Linum monogynum, *Forst.* Not uncommon on coast.

Geraniaceæ.

Geranium dissectum, *L.*, *var.* australe. General.
„ microphyllum, *Hook. f.* Generally distributed.
„ molle, *L.* Common.
Pelargonium australe, *Jacq.* Not uncommon.
Oxalis corniculata, *L.* Generally distributed.

Rutaceæ.

Phebalium nudum, *Hook.* Waitangi; Bluff.
Melicope ternata, *Forst.*, *and its var.* mantellii. Scattered throughout the district.
Melicope simplex, *A. Cunn.* Plentiful.

Meliaceæ.

Dysoxylum spectabile, *Hook. f.* Very plentiful.

Olacineæ.

Pennantia corymbosa, *Forst.* Not uncommon in woods.

Rhamneæ.

Pomaderris phylicifolia, *Lodd.* Generally distributed.

Sapindaceæ.

Dodonæa viscosa, *Jacq.* Bald Hills; Waitangi.
Alectryon excelsum, *Gærtn.* Plentiful.

Anacardiaceæ.

Corynocarpus lævigata, *Forst.* Common on coast; less common inland.

Coriarieæ.

Coriaria ruscifolia, *L.* Common.

Leguminosæ.

Carmichaelia australis, *Br.* Generally distributed.
Sophora tetraptera, *Mill.* Waitangi; Lower Waikato.

Rosaceæ.

Rubus australis, *G. Forst.* Generally distributed.
„ cissoides, *A. Cunn.* Not uncommon.
„ schmidelioides, *A. Cunn.* Not uncommon.
Potentilla anserina, *L.* Lower Waikato; not common.
Acæna sanguisorbæ, *Vahl.* Plentiful in woods.
„ novæ-zealandiæ, *T. Kirk.* Plentiful in open places.

Saxifrageæ.

Quintinia serrata, *A. Cunn.* Puni; not common.
Carpodetus serratus, *Forst.* Common in wet places.

Crassulaceæ.

Tillæa sieberiana, *Schult.* Dry sandy bank, Kariotahi.

Droseraceæ.

Drosera spathulata, *Labill.* Swamp, Te Karaka Flat.
" binata, *Labill.* General in swamps.
" auriculata, *Backh.* Common on dry hills.

Halorageæ.

Haloragis alata, *Jacq.* Generally distributed.
" tetragyna, *Hook. f.* The typical form not uncommon; var. *diffusa* plentiful.
" depressa, *Walp.* Kariotahi Gap; rare.
" micrantha, *R. Br.* Generally distributed.
Myriophyllum intermedium, *DC.* Common in streams and wet places.
" elatinoides, *Gaudich.* Lower Waikato.
" robustum, *Hook. f.* Mauku; Kariotahi.
" pedunculatum, *Hook. f.* Sand-dunes near Waikato Head: *Petrie.*
Gunnera arenaria, *Cheesem.* West Coast; plentiful.
Callitriche verna, *L.* Lower Waikato.
" muelleri, *Sond.* Common in wet places.

Myrtaceæ.

Leptospermum scoparium, *Forst.* Common.
" ericoides, *A. Rich.* Not uncommon.
Metrosideros florida, *Sm.* Common in woods.
" diffusa, *Sm.* Mauku Fall; Bald Hills.
" hypericifolia, *A. Cunn.* Common in woods.
" robusta, *A. Cunn.* Common in woods.
" tomentosa, *A. Rich.* Not uncommon on coast.
" scandens, *Soland.* Common in woods.
Myrtus bullata, *Soland.* Common.
Eugenia maire, *A. Cunn.* Edges of creeks and swamps.

Onagrarieæ.

Epilobium chionanthum, *Haussk.* Swamps; not uncommon.
" junceum, *Soland.* Not uncommon.
" [erectum, *Petrie*]. In swamps; not uncommon.
" pallidiflorum, *Soland.* In swamps; common.
" billardierianum, *Ser.* Coast; not uncommon.
" pubens, *A. Rich.* Not uncommon.
" alsinoides, *A. Cunn.* Mauku; Waitangi; rare.
" rotundifolium, *G. Forst.* Common in wet places.
" nummularifolium, *R. Cunn.* Not uncommon.
Fuchsia excorticata, *L. f.* Generally distributed.

Passifloreæ.

Passiflora tetrandra, *Banks and Sol.* Margin of woods; very plentiful and luxuriant.

Ficoideæ.

Mesembryanthemum australe, *Sol.* Sea-cliff; plentiful.
Tetragonia expansa, *Murr.* Coast; not uncommon.
" trigyna, *Banks and Sol.* Coast; not uncommon.

Umbelliferæ.

Hydrocotyle hydrophila, *Petrie.* Lower Waikato.
" dissecta, *Hook. f.* Shady places; plentiful.
" pterocarpa, *F. Muell.* Wet places; not uncommon.
" novæ-zelandiæ, *DC.* Wet places; plentiful.
" moschata, *G. Forst.* Mauku; Waiau; not common.
" asiatica, *L.* Generally distributed.
Apium australe, *Thou.* Coast; plentiful.
Apium filiforme, *Hook.* Banks of tidal creeks and brackish marshes; common.
Crantzia lineata, *Nutt.* Common in brackish marshes and moist sand.

Araliaceæ.

Panax arboreum, *G. Forst.* Generally distributed.
Schefflera digitata, *Forst.* Not uncommon in damp places.
Pseudopanax lessonii, *C. Koch.* Coast; plentiful.
Pseudopanax crassifolium, *C. Koch, var.* unifoliolatum. Generally distributed in woods.

Cornaceæ.

Corokia buddleoides, *A. Cunn.* Waitangi; not common.
Griselinia lucida, *G. Forst.* Common in woods.

Caprifoliaceæ.

Alseuosmia quercifolia, *A. Cunn.* In woods; not plentiful.

Rubiaceæ.

Coprosma grandifolia, *Hook. f.* Not uncommon in woods.
" lucida, *Forst.* Not uncommon.
" baueri, *Endl.* Coast; not uncommon.
" robusta, *Raoul.* Plentiful.
" cunninghamii. Banks of streams and damp places.
" arborea, *T. Kirk.* Common in woods.
" spathulata, *A. Cunn.* Plentiful in places.
" rotundifolia, *A. Cunn.* Swampy bush, Lower Waikato.

Coprosma areolata, *Cheesem.* Very plentiful.
" tenuicaulis, *Hook. f.* Common in damp woods.
" rhamnoides, *A. Cunn.* Not uncommon.
" rigida, *Cheesem.* Plentiful.
" acerosa, *A. Cunn.* Sand-dunes; plentiful.
" propinqua, *A. Cunn.* Damp spots; not uncommon.
Nertera cunninghamii, *Hook. f.* On wet rocks, Mauku Fall.
Nertera dichondræfolia, *Hook. f.* Plentiful in woods and swamps.
Galium tenuicaule, *A. Cunn.* Mauku, rare; Lower Waikato, common.
Galium umbrosum, *Soland.* Plentiful in woods.

Compositæ.

Lagenophora forsteri, *DC.* Generally distributed.
Olearia furfuracea, *Hook. f.* Karaka Flat; Waitangi; Waiuku.
" cunninghamii, *Hook. f.* Common in woods.
" solandri, *Hook. f.* Mauku; coast, common.
Gnaphalium luteo-album, *L.* Generally distributed.
" japonicum, *Thunb.* Generally distributed.
" collinum, *Labill.* Generally distributed.
Cassinia retorta, *A. Cunn.* Plentiful, especially near coast.
Siegesbeckia orientalis, *L.* In woods; not uncommon.
Bidens pilosa, *L.* Banks of Waikato River.
Cotula coronopifolia, *L.* Plentiful in wet places.
" minor, *Hook. f.* Not uncommon in wet places.
" dioica, *Hook. f.* Wet rocks, west coast.
Centipeda orbicularis, *Lour.* Low land; not uncommon.
Erechtites prenanthoides, *DC.* Mauku.
" arguta, *DC.* Generally distributed.
" quadridentata, *DC.* Not uncommon.
Brachyglottis repanda, *Forst.* Generally distributed.
Senecio lautus, *Soland.* Coast; common.
" kirkii, *Hook. f.* Not uncommon in woods.
Sonchus asper, *Hill, var.* littoralis. Sea-cliffs; plentiful.

Goodenovieæ.

Selliera radicans, *Cav.* Abundant in salt marshes.

Campanulaceæ.

Pratia angulata, *Hook. f.* Lower Waikato, plentiful; Mauku; Kariotahi.
Lobelia anceps, *Linn. f.* Plentiful.
Wahlenbergia gracilis, *A. DC.* Generally distributed.

Ericaceæ.

Gaultheria antipoda, *Forst.* Generally distributed.

Epacrideæ.

Cyathodes acerosa, *Br.* Generally distributed.
Leucopogon fasciculatus, *A. Rich.* Common.
" fraseri, *A. Cunn.* Generally distributed.
Epacris pauciflora, *A. Rich.* Te Karaka Flat.

Primulaceæ.

Samolus repens, *Pers.* Plentiful in salt marshes and along the coast.

Myrsineæ.

Myrsine salicina, *Heward.* Not uncommon.
" urvillei, *A. DC.* Plentiful in woods.

Oleaceæ.

Olea lanceolata, *Hook. f.* Not uncommon in woods.
" cunninghamii, *Hook. f.* Mauku.

Apocynaceæ.

Parsonsia albiflora, *Raoul.* Common in woods.
" rosea, *Raoul.* Common in woods.

Boragineæ.

Myosotis spathulata, *Forst.* Bank of creek near Puni; rare.

Loganiaceæ.

Geniostoma ligustrifolia, *A. Cunn.* Generally distributed.

Convolvulaceæ.

Calystegia sepium, *Br.* Abundant.
" tuguriorum, *Br.* Lower Waikato.
" soldanella, *Br.* Plentiful on the coast.
Dichondra repens, *Forst.* Plentiful in places.

Solanaceæ.

Solanum aviculare, *Forst.* Plentiful.
" nigrum, *L.* Generally distributed.

Scrophularineæ.

Mazus pumilio, *Br.* Moist ground, Lower Waikato.
Gratiola peruviana, *L.* Not uncommon in moist land.
" nana, *Benth.* Swamps, Te Karaka Flat.
Glossostigma elatinoides, *Benth.* Lower Waikato; west coast.
Limosella aquatica, *L.* Lower Waikato.
Veronica macrocarpa, *Vahl.* Banks of tidal creeks.
" salicifolia, *Forst.* Generally distributed.
" plebeia, *R. Br.* Low land; plentiful.

Lentibularieæ.

Utricularia novæ-zelandiæ, *Hook. f.* Swamps, Te Karaka Flat, and along the Tram.
Utricularia colensoi, *Hook. f.* Swamp, Te Karaka Flat.

Verbenaceæ.

Vitex littoralis, *A. Cunn.* Generally distributed.
Avicennia officinalis, *L.* Manukau Harbour.

Myoporineæ.

Myoporum lætum, *Forst.* Waitangi; Manukau Head.

Labiatæ.

Mentha cunninghamii, *DC.* Mauku Fall; Kariotahi Gap.

Plantagineæ.

Plantago raoulii, *Dcne.* Mauku; not common.

Chenopodiaceæ.

Chenopodium glaucum, *L.* Brackish-water swamps.
Salicornia australis, *Sol.* Along the shores.
Suæda maritima, *Dum.* Mud-flats, Waitangi.

Polygonaceæ.

Polygonum minus, *Huds.* Plentiful in wet places.
„ aviculare, *L.* Not uncommon.
Rumex flexuosus, *Sol.* Bald Hills.
Muhlenbeckia australis, *Meisn.* Plentiful.
„ complexa, *Meisn.* Abundant.

Laurineæ.

Beilschmiedia tawa, *Benth. and Hook. f.* Common.
„ tarairi, *Benth. and Hook. f.* Common.
Litsæa calicaris, *Hook. f.* Generally distributed.

Monimiaceæ.

Laurelia novæ-zelandiæ, *A. Cunn.* Plentiful in woods.
Hedycarya dentata, *Forst.* Common in woods.

Proteaceæ.

Knightia excelsa, *R. Br.* Common in woods.

Thymeleæ.

Pimelea arenaria, *A. Cunn.* Plentiful on sandhills.
„ lævigata, *Gærtn.* Common.

Euphorbiaceæ.

Euphorbia glauca, *Forst.* Common on the coast.

Santalaceæ.

Fusanus cunninghamii, *Hook. f.* Not uncommon in woods.

Urticaceæ.

Paratrophis microphylla. Not uncommon.
Elatostemma rugosum, *A. Cunn.* Lower Waikato.
Parietaria debilis, *Forst.* West coast.

Piperaceæ.

Piper excelsum, *Forst.* Plentiful in woods.
Peperomia endlicheri, *Miq.* Generally distributed.

Coniferæ.

Phyllocladus trichomanoides, *Don.* Not common.
Dacrydium cupressinum, *Sol.* Plentiful in woods.
Podocarpus ferruginea, *Don.* Plentiful in woods.
" totara, *Don.* Plentiful in woods.
" spicata, *R. Br.* Not uncommon.
" dacrydioides, *A. Rich.* Abundant in low land.
Libocedrus doniana, *Endl.* Near Waiuku; rare.
Agathis australis, *Steud.* A few scattered trees only.

Orchideæ.

Earina mucronata, *Lindl.* Plentiful in woods.
" suaveolens, *Lindl.* In woods; not common.
Dendrobium cunninghamii, *Lindl.* Not uncommon.
Bulbophyllum pygmæum, *Lindl.* Upper branches of trees; common.
Bulbophyllum tuberculatum, *Col.* Upper branches of trees, Lower Waikato, not uncommon; Mauku, rare.
Sarcochilus adversus, *Hook. f.* Branches of trees; not uncommon.
Acianthus sinclairii, *Hook. f.* In woods; common.
Microtis porrifolia, *Br.* Generally distributed.
Pterostylis banksii, *R. Br.* In woods; plentiful.
" trullifolia, *Hook.* In woods; not uncommon.
" graminea, *Hook. f.* Wet place, Mauku Fall, rare.
Thelymitra longifolia, *Forst.* Common in open land.
" pulchella, *Hook. f.* Te Karaka Flat.
Corysanthes triloba, *Hook. f.* In woods; plentiful.
" macrantha, *Hook. f.* In woods; plentiful.
" oblonga, *Hook. f.* Wet places; not uncommon.
Spiranthes australis, *Lindl.* Swamps; not uncommon.
Prasophyllum colensoi, *Hook.* One plant seen in a swamp between Mauku and Puni.
Prasophyllum pumilum, *Hook. f.* Te Karaka Flat.
Orthoceras solandri, *Lindl.* Not uncommon in open places.

Liliaceæ.

Rhipogonum scandens, *Forst.* In woods; plentiful.
Phormium tenax, *Forst.* Creek-banks, edges of swamps; common.
Cordyline australis, *Hook. f.* Generally distributed.
" banksii, *Hook. f.* Dry woods; not uncommon.
" pumilio, *Hook. f.* Among scrub; not uncommon.
Astelia cunninghamii, *Hook. f.* On cliffs and rather dry spots.
" solandri, *A. Cunn.* Common in woods.
" banksii, *A. Cunn.* Common in woods.
" grandis, *Hook. f.* Swampy places; not common.
Arthropodium cirrhatum. Not uncommon on sea-cliffs.
Dianella intermedia, *Endl.* Common.

Juncaceæ.

Juncus maritimus, *L.* Common in salt marshes.
" effusus, *L.* Generally distributed.
" planifolius, *Br.* Wet places; common.
" cæspititius. Wet places near the coast.
" prismatocarpus. Wet places; plentiful.
" bufonius, *L.* Not uncommon.
Luzula campestris, *DC.* Vicinity of Mauku.

Palmeæ.

Rhopalostylis sapida, *Wendl. and Druce.* Common in woods.

Typhaceæ.

Typha angustifolia, *L.* Abundant in swamps.
Sparganium simplex, *Huds.* Common in swamps.

Pandaneæ.

Freycinetia banksii, *A. Cunn.* Common in suitable localities.

Lemnaceæ.

Lemna minor, *L.* Not uncommon in still water.

Naiadaceæ.

Triglochin triandrum, *Michaux.* Common in salt marshes, and in moist sand on the coast.
Potamogeton cheesemanii, *A. Bennett.* Common in streams.
" ochreatus, *Raoul.* Waikato River.
" polygonifolius, *Pourr.* Common in wet places.
Zostera marina, *L.* Manukau Harbour and tidal creeks.

Restiaceæ.

Leptocarpus simplex, *A. Rich.* Brackish-water marshes, plentiful; Mauku Creek (fresh water).

Cyperaceæ.

Cyperus ustulatus, *A. Rich.* Plentiful in wet places.
Eleocharis sphacelata, *Br.* Wet swamps; not uncommon.
„ acuta, *Br.* Common in swampy places.
„ gracillima. Common in swamps.
Scirpus cernuus, *Vahl.* (S. riparius, *Br.*). Common.
„ inundatus, *Poir.* Plentiful in wet places.
„ prolifer. Not uncommon in swamps.
„ nodosus, *Rottb.* Generally distributed.
„ lacustris, *L.* Banks of streams; common.
„ maritimus, *L.* Waikato River; Mauku Creek; coast.
„ frondosus, *Banks and Sol.* Sandhills; common.
Schœnus axillaris, *Poir.* Common in wet places.
„ tenax, *Hook. f.* Te Karaka Flat; not common.
„ tendo, *Banks and Sol.* Te Karaka Flat; common.
„ carsei, *Cheesem.* Te Karaka Flat; not common.
Lepidosperma australe, *R. Br.* Generally distributed.
„ concava, *R. Br.* Te Karaka Flat; common.
Cladium articulatum, *Br.* In swampy places; common.
„ glomeratum, *Br.* Common in swamps.
„ teretifolium, *Br.* Common in swamps.
„ gunnii, *Hook. f.* Common throughout the district.
„ junceum, *Br.* Brackish-water marshes; abundant.
„ sinclairii, *Hook. f.* Cliffs of tidal creeks
„ capillaceum, *C. B. Clarke.* Common in swampy places.
Gahnia hectori, *Kirk.* Mauku; not common.
„ lacera, *Steud.* Not uncommon.
„ gaudichaudii, *Steud.* Dry places; not uncommon.
„ setifolia. Wet places; common.
Uncinia australis, *Pers.* Common in woods.
„ banksii, *Boott.* Common in dry woods.
Carex paniculata, *L.* The varieties *secta* and *virgata* are plentiful in swamps.
„ inversa, *R. Br.* Bank of Waikato, rare; Bald Hills, rare.
„ subdola, *Boott.* Generally distributed in wet places.
„ ternaria, *Forst.* Common in wet places.
„ lucida, *Boott.* Generally distributed.
„ dipsacea, *Berggren.* Between Mauku and Lower Waikato.
„ testacea, *Sol.* Not uncommon on the coast.
„ littorosa, *Baker.* Muddy flats, Mauku (tidal) Creek.
„ dissita, *Soland.* The typical form, var. *a lambertiana* and var. γ, are common throughout the district.
„ neesiana, *Endl.* Vicinity of Mauku.
„ breviculmis, *R. Br.* Dry hills; common.
„ pumila, *Thunb.* Sandy coast; common.

Carex vacillans, *Sol.* Bald Hills.
  „ pseudo-cyperus, *L.* Common in wet land.

Gramineæ.

Microlæna stipoides, *Br.* Throughout the district.
  „ arenacea, *Hook. f.* Common in woods.
Hierochloe redolens, *Br.* Wet places, Mauku; coast.
Spinifex hirsuta, *Labill.* Common on the coast.
Paspalum distichum, *Burmann.* Bank of Waikato River and moist brackish marshes.
Oplismenus undulatifolius, *Beauv.* Common in woods.
Isachne australis, *Br.* Swamps; plentiful.
Zoysia pungens, *Willd.* Common on sand-dunes.
Stipa micrantha, *Nees.* Brackish-water marshes.
Dichelachne crinita, *Hook. f.* Not uncommon.
  „ sciurea, *Hook. f.* Generally distributed.
Deyeuxia forsteri, *Kunth.* Common.
  „ billardieri, *Kunth.* Brackish swamps; common.
  „ quadriseta, *Benth.* Not uncommon.
Arundo conspicua, *Forst.* Sandhills and inland swamps; plentiful.
Poa anceps, *Forst.* Not uncommon.
  „ australis *var.* lævis. Wet places on the coast.
Danthonia semi-annularis, *Br.* Generally distributed.

Filices.

Gleichenia circinata, *Swz.* Generally distributed.
  „ dicarpa, *Br.* Common.
  „ cunninghamii, *Hew.* The Bluff; not common.
Cyathea medullaris, *Swz.* Common in woods.
  „ dealbata, *Swz.* Common in woods.
Hemitelia smithii, *Hook.* Mauku; two plants only.
Dicksonia squarrosa, *Swz.* Common in woods.
Hymenophyllum tunbridgense, *Sm.* Common in woods.
  „ multifidum, *Swz.* Patumahoe; rare.
  „ rarum, *Br.* Not uncommon.
  „ polyanthos, *Swz.* Common in woods.
  „ javanicum, *Spreng.* On rocks; not uncommon.
  „ dilatatum, *Swz.* In woods; common.
  „ demissum, *Swz.* Plentiful in woods.
  „ scabrum, *A. Rich.* Mauku; rare.
  „ flabellatum, *Labill.* In woods; not uncommon.
  „ subtilissimum, *Kunze.* Mauku; rare.
Trichomanes reniforme, *Forst.* In woods; not common.
  „ humile, *Forst.* On damp rocks; not uncommon.
  „ venosum, *Br.* On tree ferns; common.

Trichomanes rigidum, *Swz.*, *var.* elongatum. Shady clay banks; common.
Davallia novæ-zelandiæ, *Col.* Mauku; rare.
Lindsaya linearis, *Swz.* Te Karaka Flat; plentiful.
„ viridis, *Col.* Mauku, on stems of ferns; not common.
Adiantum diaphanum, *Blume.* Creek-sides; not uncommon.
„ affine, *Willd.* Common.
„ fulvum, *Raoul.* Not uncommon.
„ æthiopicum, *L.* Mauku; not uncommon.
„ hispidulum, *Swz.* Mauku; rare.
Hypolepis tenuifolia, *Bernhard.* Not common.
„ distans, *Hook.* Mauku, plentiful; Lower Waikato.
Pellæa rotundifolia, *Hook.* Common in woods.
Pteris tremula, *Br.* Plentiful in woods.
„ scaberula, *A. Rich.* Mauku; Puni; Lower Waikato. Not common.
„ macilenta, *A. Cunn.* In woods; plentiful.
„ comans, *Forst.* Puni; one plant. Plentiful along the coast.
„ aquilina, *L.*, *var.* esculenta. Generally distributed.
„ incisa, *Thunb.* Not uncommon.
Lomaria discolor, *Willd.* In woods; plentiful.
„ lanceolata, *Spreng.* Banks of creeks, &c.; common
„ procera, *Spreng.* Generally distributed.
„ filiformis, *A. Cunn.* In woods; plentiful.
„ fluviatilis, *Spreng.* Bald Hill bush; rare.
„ membranacea, *Col.* In woods; not uncommon.
„ frazeri, *A. Cunn.* In woods; common.
Doodia media, *R. Br.* Not common.
Asplenium obtusatum, *Forst.*, *var.* obliquum and *var.* lucidum. Common in woods.
„ falcatum, *Lamarck.* Plentiful in woods.
„ hookerianum, *Col.* Mauku; Lower Waikato.
„ bulbiferum, *Forst.* Plentiful in woods.
„ flaccidum, *Forst.* Common in woods.
„ umbrosum, *J. Smith.* Not common.
Aspidium richardii, *Hook.* On rocks; not uncommon.
„ capense, *Willd.* Usually an epiphyte; common.
Nephrodium thelypteris, *Desv.*, *var.* squamulosum. Swamp, Lower Waikato; not common.
„ decompositum, *R. Br.* Not common.
„ glabellum, *A. Cunn.* In woods; plentiful.
„ hispidum, *Hook.* Common in woods.
Polypodium punctatum, *Thunb.* Generally distributed.
„ pennigerum, *Forst.* Plentiful throughout the district.
„ grammitidis, *R. Br.* Not uncommon.
„ tenellum, *Forst.* In woods; not uncommon.

Polypodium cunninghamii, *Hook.* On rocks and tree-trunks; plentiful.
" serpens, *Forst.* Common throughout the district.
" pustulatum, *Forst.* In woods; plentiful.
" billardieri, *Br.* Generally distributed.
Todea hymenophylloides, *Rich. and Less.* Banks of creeks; common.
Schizæa fistulosa, *Labill.* Te Karaka Flat; common.
" bifida, *Swz.* Te Karaka Flat; plentiful.
Lygodium articulatum, *A. Rich.* Common in woods.
Marattia fraxinea, *Sm.* Bald Hills, not uncommon; Puni; Manukau Head, in deep gully.

Ophioglosseæ.

Ophioglossum vulgatum, *L.* Bank of Waikato River.
Botrychium ternatum, *Swz.* In scrub; not uncommon.

Salvinieæ.

Azolla filiculoides, *Lam.*, *var.* rubra. Swamps, Lower Waikato.

Lycopodiaceæ.

Lycopodium billardieri, *Spreng.* In woods; not uncommon.
" densum, *Labill.* Among scrub; common.
" cernuum, *L.* Clay cliffs, the Bluff; rare.
" laterale, *Br.* In damp open places; common.
" scariosum, *Forst.* Clay cliffs, the Bluff; rare.
" volubile, *Forst.* Generally distributed.
Tmesipteris tannensis, *Bernh.* In woods; common.

Art. XXXIII.—*Notes on the Growth of some Indigenous and other Trees in New Zealand.*

By H. D. M. Haszard.

[*Read before the Auckland Institute, 7th October, 1901.*]

Through the courtesy of Mr. J. W. Hall, of the Thames, who for the last thirty years has made a hobby of arboriculture, I have been enabled to take the measurements of a number of trees growing on his estate at Parawai, Thames, which may possibly be worth placing on record.

The situation of Mr. Hall's plantation is on the rising ground at Parawai, the lower portion dipping into a gully and being fairly well sheltered, the upper part rather exposed to the southerly winds, the whole having a south-westerly aspect,

with high hills at the back cutting off the morning sun. The soil is a stiff clay of rather poor quality.

Mr. Hall informs me that the plants when set out were seedlings that would average about 6 in. in height; but, as Mr. Hall is himself sending a paper describing his method of operations, it is not necessary for me to do more than give the measurements as taken, except that I would like to emphasize his remarks on the advantage of more being done in the way of planting native trees, and making it generally known that a great many of them may be propagated from cuttings.

The girths given by me have in all cases been taken at 1 ft. from the ground, with the exception of the last on the list, which is a magnificent specimen of *macrocarpa*, growing on my place at Mount Pleasant, and whose gnarled roots necessitated the measurements being taken at 3 ft. above the surface. It is a beautiful symmetrical tree, 62 ft. in height, and its branches cover a circle 216 ft. in circumference. From what I can gather it was planted about 1872. All heights have been taken approximately with an Abney level.

No. of Specimen.	Name.	Girth.		Height.		When planted.
		Ft.	in.	Ft.	in.	
1	Kauri (*Agathis australis*)*	1	10	36	0	1877
2	" "	1	11	34	0	1878
2A	" (*A. mooreii*)†	1	7	22	0	1878
3	Puriri (*Vitex littoralis*)‡	4	4	39	0	1872
4	" "	2	10½	36	0	1877
5	Matai (*Podocarpus spicata*)	0	7½	14	0	1877
6	Totara (*Podocarpus totara*)	2	9	42	0	1873
7	" "	2	4	39	0	1873
9	Miro (*Podocarpus ferruginea*)	1	1	16	0	1876
11	Kahikatea (*Podocarpus dacrydioides*)	1	6	35	0	1876
12	Rimu (*Dacrydium cupressinum*)	1	10	33	0	1873
13	" " §	1	11	35	0	1874
14	" "	1	6	22	0	1878
15	Kawaka (*Libocedrus doniana*)	1	11	24	0	1875
16	Tanekaha (*Phyllocladus trichomanoides*)	1	7	32	0	1876
17	" "	1	9	30	0	1878
18	Mammoth of California (*Wellingtonia sequoia*)	5	3	56	0	1873
19	Blue-gum (*Eucalyptus globulus*)	8	7	74	0	1872
20	Peppermint gum (*Eucalyptus amygdalina*)	6	5	48	0	1875
21	Stringy-bark gum (*Eucalyptus obliqua*)	7	4	70	0	1875
22	" "	7	0	67	0	1875
23	*Cupressus macrocarpa*	14	9	62	0	1872

* Cone-bearing for three years. † From New Caledonia. ‡ Branches at 3 ft. from the ground. § Well sheltered.

Art. XXXIV.—*Remarks on New Zealand Trees planted at Parawai, Thames, at and subsequent to the Year 1873.*

By J. W. Hall.

[*Read before the Auckland Institute, 7th October, 1901.*]

It is much to be regretted that a well-organized arboretum for indigenous trees and shrubs has not been established in each of the great centres of population. The extensive, and frequently wanton, destruction of the native bush has been going on at such a pace that it will soon be difficult, if not impossible, to get sight of some of the rarer species. And, unfortunately, the planting of our beautiful New Zealand trees has not generally been adopted, perhaps from the mistaken idea that they are difficult of culture. Partly to disprove this, but principally because I had a great liking for the occupation, I some thirty years ago began a plantation on a piece of land at Parawai, Thames. My success may be gauged by the report just read by Mr. Haszard, giving the data and measurements he has so kindly taken.*

One plantation is in a rather shallow gully, and is about an acre in extent; the other is on a gently rising hill, and is about 2 acres. The trees are grown under almost natural conditions, without cultivation, and were generally less than 1 ft. high when planted. A hole about 2 ft. square was dug for their reception, and a handful of bonedust added. The plants were then left almost unattended, except that the fern and scrub were occasionally cleared from around them. Unfortunately, a few fir trees, originally intended for shelter, were left too long—indeed, some are there yet—and thus the growth was impeded.

Measurements of the pohutukawa and puriri were difficult to obtain, as these trees, especially the pohutukawa, run much to branches. The latter tree should be more extensively planted than it is at present. It is easily grown, and, unlike most New Zealand trees, will bear a slight scorching. It would be a very suitable tree for planting on railway cuttings and embankments, as its closely matted roots would prevent the ground from slipping. One of my pohutukawas, planted about thirty years ago, is quite 40 ft. high, and makes a prodigious display of deep-crimson blossoms about Christmas time. It is greatly to be regretted that more of these fine and useful trees have not been planted in the Auckland Domain and

* See Art. XXXIII.

Albert Park. The Domain might easily be converted into a splendid arboretum of New Zealand trees.

Compared with *Cupressus macrocarpa*, *Pinus insignis*, and the *Eucalypti*, our indigenous trees are certainly of slow growth; but in a favourable situation and suitable soil the kauri, rimu, totara, puriri, and others make fairly rapid progress and require very little attention, though cultivation and bonedust will certainly hasten their growth. The aspiring development of the kauri, the deep-green foliage of the puriri and karaka, and the graceful habit of a young rimu are all very attractive to the lover of trees.

Some of the shrubs and low-growing trees are also very beautiful—for instance, the whau, the leaves of which sometimes exceed 1 ft. in width and 2 ft. in length. The climbing ratas (*Metrosideros*) are also well worthy of attention. *M. diffusa*, displaying its wealth of crimson blossoms early in the spring, *M. albiflora*, laden with large white flowers late in December, and the scarlet *M. florida* in the early autumn, are well worthy of cultivation, and, though difficult to transplant, grow freely from seed. This, however, is a slow process, but if planting were carried on extensively it would have to be resorted to.

Cultivators are too apt to think that selecting a large specimen will insure rapid development, whereas the reverse is generally the result. It may not be generally known that the puriri and totara, and doubtless many others, can be grown from cuttings. Surrounding part of my plantation is a well-established totara fence grown exclusively from cuttings.

Besides the trees mentioned in Mr. Haszard's list, there are many others too recently planted to make the measurements worth recording. Additions are constantly being made to my collection to replace failures and establish fresh species. Some of the commonest kinds I have found most difficult of cultivation. I have not yet succeeded with the tawa, the taraire, or the pukatea. Perhaps the most troublesome of all are the semi-alpine ones—they suffer so much from the drought in summer and the frost in winter.

One object in making these plantations was to induce the visits of our rapidly disappearing native birds. The frequent visits of the riro-riro, the piwakawaka, and the kotare, with occasional incursions of the ruru, the tui, and the pipiwharauroa, and still more rare appearance of the kaka, kukupa, kohoperoa, weka, and miromiro, have amply repaid my expectations.

In conclusion, let me express a hope that these few cursory remarks may induce others to attempt the cultivation of our indigenous flora.

Art. XXXV.—*Descriptions of New Native Plants, and Notes.*

By D. Petrie, M.A.

[*Read before the Auckland Institute, 5th August, 1901.*]

1. **Epilobium erectum,** sp. nov.

Stems simple, erect, rigid, terete, stout, 3 ft.–5 ft. high, reddish, glabrescent or sparingly pubescent with rather long curved hairs, marked by ridges decurrent from the edges of the sessile leaves, sparingly leafy, the successive leaves or pairs of leaves barely overlapping or more distant. Leaves contracted at the broadly sessile base, opposite below, alternate above, ovate-lanceolate to linear-lanceolate, tapering uniformly to the acute tips, membranous, 1½ in.–2½ in. long; closely, shortly, bluntly, and regularly toothed along the margin, the midrib and nerves prominent; glabrous or pubescent on the midrib, nerves, and edges, gradually diminishing upwards, the lower often bearing undeveloped shoots in their axils. Inflorescence much branched, the lower branches long and leafy, all springing from the axils of leafy bracts. Flowers numerous, clustered, short, nearly sessile, densely and loosely pubescent, opening singly and for a short time only. Calyx deeply divided, the lobes narrow linear-lanceolate, acute, finely pilose. Petals magenta or paler, one-half longer than the calyx (rarely twice as long), shortly 2-lobed, the lobes obtuse. Pedicels of mature capsules ¼ in. long or less, capsules slightly curved, 2½ in. long, tapering at the apex; like the pedicels, hoary with fine loosely appressed longish pubescence. Seeds ovate, flattened on one side; testa papillose.

Hab. Wet and boggy stations in the lowlands of Auckland Province—Dargaville, Whangarei, St. John's Lake (Auckland), Port Charles, marshes of Lower Waikato, Morrinsville, Pongakawa, Matata; Kaitoke Valley (Wellington); and north-western lowlands of Nelson. I have not observed it in Canterbury or Otago.

The leaves are sometimes gradually narrowed at the base, especially in shaded situations. Where several stems grow up together, as sometimes happens when the main stem is broken off or arrested, the lower leaves often present the same feature. The ridges on the internodes are usually four, but occasionally adjoining pairs coalesce. At Kaitoke, in a small bog surrounded by tall forest, I gathered specimens 6 ft. high and as stout as one's little finger.

The present species is *E. junceum*, Solander, var. *macrophylla*, Haussknecht. Mr. Kirk appears not to have known

it, as he does not refer to the variety in his "Students' Flora of New Zealand." It differs from *E. junceum* in a number of characters that are constant throughout a range extending over more than half the colony. These characters are the simple stout glabrescent tall stems, the large ovate- or linear-lanceolate membranous glabrescent strongly nerved leaves, and the much-branched leafy inflorescence with shortly pedicelled capsules. The spacing of the leaves on the stems is remarkably uniform and elegant. Only *E. pallidiflorum*, Solander, and *E. chionanthum*, Haussk., approach it in height and robustness. It is not a hybrid between these species or any others. In the marshes of the Waikato it is a most abundant plant, and imparts to them a distinct facies that is easily recognised from the windows of railway-carriages.

2. Note on **Ehrharta thomsoni**, Petrie.

I can now record the occurrence of this grass in the Auckland Islands, having recently found a number of short flowerless stems in a tuft of *Poa* gathered there by Mr. F. R. Chapman in January, 1890. The foliage of the species is so characteristic that I have no doubt of the accuracy of this determination. In Mr. Cheeseman's herbarium I have also seen similar flowerless specimens from the mountains in the neighbourhood of Westport, where they were collected by Mr. Townson. The species thus proves to have quite an extensive range.

3. Note on **Danthonia australis**, Buchanan.

This species extends to Campbell Island, as is proved by a specimen given me, a good many years ago, by Mr. Buchanan, under the name "*Danthonia raoulii*, Hook. f." The specimen is quite distinct from the latter species, and is doubtless part of a young tuft of *D. australis*. The stem is short and unbranched, but in all other respects the grass matches typical specimens from the mountains of the Nelson District. The occurrence of these grasses on the southern off islands establishes further links in the close botanical connection between them and the main islands of New Zealand.

4. **Poa seticulmis**, sp. nov.

Tufted or spreading, branched below, slender, smooth, pale-green or yellowish, 4 in.–10 in. high. Leaves shorter than the culms, very slender or filiform, erect, striate, smooth, involute. Sheaths broad, membranous, striate, and grooved; contracted just below the short broad ligule. Culms erect, slender, often filiform, perfectly smooth, clothed almost to the top by the sheaths of the cauline leaves. Panicle ovate, 1½ in.–3 in. long; the branches in pairs, ascending or

almost divaricating, sparingly subdivided, scabrid, bearing few shortly pedicelled spikelets at the tips of the branchlets. Spikelets rather small, narrow, very uniform, pale, polished and shining, glabrous, about $\frac{1}{6}$ in. long, 3- to 5-flowered, obscurely nerved. Empty glumes shorter than the flowering, about half the length of the spikelet, membranous, narrow, acute, subequal. Flowering-glumes coriaceous, subacute, faintly 3- to 5-nerved, glabrous or slightly downy on the back, webbed at the base, sometimes serrate along the midrib, as is occasionally the case in the empty glumes also; palea rather stiff.

The typical state of this grass is that found on sandhills on the west coast of the North Island to the north of the Waikato Heads, but I cannot separate from it by any good or constant characters a darker-green inland form that ranges throughout both Islands as far south as Catlin's River, in the south-east of Otago.

Its closest affinity is with *Poa colensoi*, Hk. f., and *Poa pusilla*, Berggren. I consider it impossible to identify the typical sandhill plant with Berggren's species, but some of the inland forms included in my species approximate to what appear to be large forms of Berggren's plant. Specimens from distant and diverse stations display great uniformity of character. Variation is chiefly seen in the flatness or involution of the leaves, woodland specimens being decidedly flatter, the scabrid serrature of the back of the glumes, and the extent of the downiness and the webbing at the base of the flowering-glumes. I have not noticed any panicle having more than two branches at one node.

The present species has been long known, but it was confounded with *Poa breviglumis*, Hook. f., by most botanists, and most likely by Hooker himself. It is now certain that it does not belong to that species. The following stations are from labels in my herbarium: Typical form—Ahipara Bay, Maunganui Bluff, Kaipara Heads, Waitakerei West, Manukau Heads. Inland form—Opanaki (Kaihu Valley), Tirau (Upper Thames), Hiruharama (Waipiro Bay), Bealey (Canterbury Alps), Maungatua, Catlin's River. A number of my specimens have been received from Mr. Cheeseman and Mr. Kirk, those of the latter under the name "*Poa breviglumis*, Hk. f.," an identification which Mr. Kirk abandoned in later years.

5. **Poa matthewsii**, sp. nov.

A slender tufted or spreading grass, in the typical form sparingly leafy, 10 in.–20 in. high. Stems branched at the base, striate and grooved, smooth, clothed at anthesis to the base of the panicle by the sheaths of the cauline leaves. Leaves narrow, flat or involute, glabrous, longer than the

pale grooved sheaths; ligule oblong. Panicle narrow (in the typical form) or effuse, usually inclined, 10 in. long or less, distantly branched; branches 2–4, capillary, glabrous or scabrid, sparingly subdivided, bearing few small shortly pedicelled spikelets chiefly along their upper half. Spikelets small, narrow-ovate, $\frac{1}{8}$ in. long and about half as broad, usually 4- to 6-flowered, the flowers sessile and crowded on the rachis. Empty glumes unequal, membranous, subacute, half as long as the flowering-glume next above. Flowering-glumes compressed, green or pale, membranous, 5-nerved, acute, glabrous or slightly scabrid on the nerves, not webbed at the base, the midrib scabrid; palea two-thirds the length of the glume.

Hab. Waipahi, Kelso, and Cromwell, in Otago, on alluvial flats.

Besides the typical form, I have two well-marked varieties of this grass.

Var. *minor.*—Plant shorter and more densely tufted; leaves slender, involute, much shorter than the culms; panicles shorter and more effuse; spikelets smaller and fewer flowered. This variety grows at Ngapara, near Oamaru, and is most abundant on alluvial flats in the Manuherikia Plain, in Central Otago. A form closely akin to it occurs at Kakanui Mouth, but its panicle is long and very effuse, and the flowers, though small, are normal in number.

Var. *tenuis.*—Very slender, spreading, with flat leaves and long narrow green spikelets; flowers more distant, with acute strongly nerved glumes that are sometimes slightly webbed at the base. This variety was abundant in valley-bottoms in the Catlin's River district before settlement began. The clearing of the bush and the attacks of stock have since almost exterminated it in this district. A better series of specimens than I now possess might prove that var. *tenuis* is an independent species. Unfortunately, the rich collection of specimens from various stations that I once possessed has been lost, through being lent to the late Mr. T. Kirk to aid him in his preparation of a new Flora of New Zealand.

The present grass is of considerable economic value, and would well repay cultivation. It is now to be found only in spots protected from cattle and sheep by shrubby thickets and bushes of *Phormium.* Var. *minor* is, however, still abundant, but its value is much less.

Poa matthewsii is, no doubt, one of the grasses of the main islands that Sir Joseph Hooker included in *Poa breviglumis,* a species, so far as we know, confined to the southern off islands. It is easy to understand how Hooker, with his scanty materials and his desire to avoid setting up invalid

species, came to mass into one specific congeries several distinct plants. It is certain that no form of *Poa breviglumis*, Hk. f., collected on the main islands exists in any colonial herbarium.

The species is named in compliment to Mr. H. J. Matthews, of the State Forest Department, who has contributed much useful material to my collection, and has for a number of years done notable service to New Zealand botany by collecting and growing numbers of alpine and other interesting native plants. His cultivated series of *Veronicas*, *Celmisias*, *Olearias*, *Ourisias*, &c., are of remarkable interest. His garden at Hawthorn Hill, Mornington, Dunedin, is well worth a visit from any one interested in the rarer and more beautiful native plants.

6. **Poa incrassata,** sp. nov.

A very short, densely tufted, perfectly glabrous grass, 2 in.–3 in. high. Culms hardly exceeding the leaves, but elongating slightly in fruit, branched at the base, glabrous. Leaves folded, the folded sides appressed, not involute, nearly setaceous; sheaths broader, grooved, almost as long as the blades; ligule very short. Panicle ½ in.–1 in. long, branches few and short, not scabrid. Spikelets 6 or fewer, on pedicels twice their own length, ⅛ in. long and nearly as broad, turgid, purplish-brown, usually 4-flowered. Empty glumes unequal, broad, obtuse, half as long as the nearest flowering-glume. Flowering-glumes slightly incurved at the tip, obtuse, coriaceous, distinctly 5-nerved, the midrib very prominent, not scabrid and not webbed at the base; palea nearly as long as the glume.

Hab. Auckland Islands. Collected by Mr. F. R. Chapman, of Dunedin, in January, 1890.

7. **Poa chathamica,** sp. nov.

Loosely tufted or spreading by wiry rhizomes, leafy below, 1 ft.–1½ ft. high, growing in *Sphagnum* swamps. Leaves flat, narrow, grooved and striate, subrigid, ending in stiff rather sharp points; the lower sheaths much shorter than the blades; ligule very short, marked by a band of short stiff hairs. Culms 1 ft.–1½ ft. high, erect, rigid, smooth, pale. Panicles contracted, narrow-ovate or almost linear, 2 in. long or less, sparingly branched; the branches capillary, scabrid, springing in pairs from alternate sides of the rachis. Spikelets 4- to 5-flowered, ovate, ¼ in. long, pale or purplish, almost sessile. Empty glumes nearly equal, lanceolate, acute, somewhat incurved, 3-nerved, scabrid along the midrib above, half as long as the spikelets. Flowering-glumes subacute, strongly 5-nerved, glabrous (in the typical form),

more or less ciliate along the margin and the midrib, sparingly webbed at and above the base; palea almost as long as the glume, 2-nerved, nerves ciliate.

Hab. *Sphagnum* bogs at the Chatham Islands, where it was collected by Messrs. L. Cockayne and F. A. D. Cox in January, 1900.

Mr. Cockayne writes me that he considers this a grass of great economic importance. He has seen about 100 acres of worthless quaking peat bog, from which the natural covering of heath and sedge had been burned off, occupied so closely by this grass that the land looked like a planted cornfield. He thinks it will prove of great value in wet, sour lands. The rhizomes spread with such vigour that it would not be readily eaten out by stock.

In my collection are specimens of this grass from the Auckland or Antipodes Islands, collected by Mr. T. Kirk, and sent to me under the name of "*Festuca scoparia*, Hook. f." It differs from the typical plant of the Chatham Islands in the long, rigid, involute leaves equalling the culms, in the nearly linear panicle, and in the soft pubescence of the glumes. It is clearly a form of the present species, and presents only such subvarietal differences as might be expected from the difference of habitat combined with long isolation. It is no doubt the same grass as Mr. Buchanan referred to *Poa foliosa*, Hook. f. It is much more closely related to *Poa anceps*, Forster.

8. *Agropyrum coxii*, sp. nov.

Densely tufted, slender, leafy, about 18 in. high. Leaves longer than the culms, very slender, involute, terete, perfectly smooth, limp and pliant, midrib and striæ obscure, the lower incurved edges delicately serrate. Sheaths much shorter than the blades, and three or four times as broad, smooth, finely puberulent, striate but not grooved; ligule short. Culms erect or slightly geniculate, slender, leafy to the base of the flowering-spike, which is 3 in. long. Rachis once branched at the base, the branch short and bearing two or three spikelets. Spikelets (including the awns), $\frac{7}{12}$ in. long, 3- to 5-flowered, the lower pedicellate, the upper sessile. Empty glumes half as long as the spikelet or less, unequal; the lower narrow-linear, acute, ending in a terete scabrid point, midrib obscure; the upper narrow-lanceolate, 3-nerved below, produced into a long terete scabrid point. Flowering-glumes coriaceous, boat-shaped, produced into a long, tapering, scabrid awn that is as long as the glume or longer than it, faintly nerved, finely scabrid, serrate along most of the back; veins of the palea prominent, remotely ciliate.

Hab. Seaside rocks and sands at the Chatham Islands. Collected by Messrs. L. Cockayne and F. A. D. Cox.

This grass is no doubt a true *Agropyrum*, in spite of its branching rachis and pedicellate spikelets. The species is named in compliment to Mr. Cox, who has done a great deal to advance our knowledge of the interesting flora of the Chatham Islands, where he has long been resident.

Art. XXXVI.—*The Vegetable Caterpillar* (Cordiceps robertsii).

By H. Hill, B.A., F.G.S.

[*Read before the Hawke's Bay Philosophical Institute, 21st October, 1901.*]

Plate XXI.

There is a small company of active scientific inquirers along the east coast of this North Island. In order to put down their thoughts and gain information from others of like tastes to themselves they issue a newspaper in manuscript, known as the "East Coast Naturalist." In one of the numbers of this interesting publication appears a letter signed "W. M.," in which the writer calls attention to an article by James Buckland on the "Vegetable Caterpillar." "W. M." does not say where the article appears, but mention is made of the differences between the generally accepted information concerning the caterpillar (*Cordiceps robertsii*) and the information given by Mr. Buckland. No doubt there is a good deal of misapprehension with respect to this curious product, and it may be that a study of its life-history will even prove of benefit to the students of bacteria in relation to their effects on animal organisms.

Comparatively little appears to be known concerning the vegetable caterpillar beyond the fact that it is found in certain places in the North Island of New Zealand. The first published account of the caterpillar is in the "Tasmanian Journal of Science" for the year 1842. In vol. i., pages 307, 308, there is an account, accompanied by two illustrations, of the bulrush caterpillar (*Sphæria robertsii*), native name "aweto-hotehe," by the Rev. R. Taylor, Waimate, New Zealand. "This singular plant"—so runs the account—"which is a native of New Zealand, may be classed amongst the most remarkable productions of the vegetable kingdom. . . . The aweto is only found at the root of a particular tree—the rata. The female pohutakara (*sic*), the root of the plant which in every instance exactly fills the

body of the caterpillar in the finest specimens, attains a length of 3½ in., and the stem which germinates from this metamorphosed body of the caterpillar is from 6 in. to 10 in. high. Its apex when in a state of fructification resembles the club-headed bulrush in miniature, and when examined with a powerful glass presents the appearance of an ovary. There are no leaves; a solitary stem comprises the entire plant, but if any accident break it off a second stem arises from the same spot. The body is not only always found buried, but the greater portion of the stalk, as well as the seed-vessel, alone is above ground. When the plant has attained its maturity it soon dies away. These curious plants are far from being uncommon. I have examined at least a hundred. The natives eat them when fresh, and likewise use them when burnt as colouring-matter for their tattooing, rubbing the powder into the wounds, in which state it has a strong animal smell. When newly dug up the substance of the caterpillar is soft, and when divided longitudinally the intestinal canal is distinctly seen. Most specimens possess the legs entire, with the horny part of the head, the mandibles, and claws. The vegetating process invariably proceeds from the nape of the neck, from which it may be inferred that the insect, in crawling to the place where it inhumes itself prior to its metamorphosis, whilst burrowing in the light vegetable soil, gets some of the minute seeds of this fungus between the scales of its neck, from which in its sickening state it is unable to free itself; and as a consequence these, being nourished by the warmth and moisture of the insect's body, then lying in a motionless state, vegetate, and not only impede the process of change in the chrysalis, but likewise occasion the death of the insect. That the vegetating process thus commences during the life of the insect appears certain from the fact of the caterpillar, when converted into a plant, always preserving its perfect form; in no one instance has decomposition appeared to have commenced, or the skin to have contracted or expanded beyond its natural size."

The "Transactions of the New Zealand Institute" contain some information on this interesting question, but no experiments seem to have been carried on by any of those who have written on the subject, and the information that contains the first descriptive account of the hotehe is perhaps as full and as correct as anything that has since appeared.

In the "Proceedings of the Wellington Philosophical Society," 14th November, 1894, there is an abstract of a paper on vegetable parasites by the late W. M. Maskell, and some valuable remarks are given as to the action of vegetable parasites on insects. Referring to the house-fly fungus (*En-*

tomophthora muscæ) and various fungi that attack homopterous bush insects, the vegetable caterpillar came under notice. "The grub," said Mr. Maskell, "was stated to be the larva of some large moth, probably of the genus *Hepialus*, and the fungus belonged to the genus *Cordiceps*. The action of the fungus on the insect was practically the same as in the case of the fungus on the house-fly, as it took possession of and destroyed all the internal organs; but, as the caterpillar was subterranean, the fungus, in order to reach the air and scatter its spores, pushed out a long stem through the earth, and at the extremity of the stem the 'asci,' or small bags containing the spores, were developed."

Following Mr. Maskell's remarks, Sir Walter Buller ventured to challenge Mr. Maskell's description of the vegetable caterpillar, because he considered it unscientific and misleading, and he pointed out that in Mr. E. Wakefield's book, "New Zealand after Forty Years," there was an erroneous figure of the vegetable caterpillar, which was represented as lying horizontally, with the stems growing upwards at a right angle with the body. Mr. T. W. Kirk at the same time remarked that specimens of *Hepialus* do not take to the ground, and that the stems of the vegetable caterpillar "grow from either end, and from both ends, of the single specimen."

In the "Transactions of the New Zealand Institute" for 1894, page 155, Sir Walter Buller has a paper on the vegetable caterpillar, but he brings no new facts to bear on the life-history of this interesting insect. He gives, however, the following statement from the late Mr. Skey, then Government Analyst, touching the so-called skin of the vegetable caterpillar: "The skin does not give any indication of the presence of chitine or other animal substance. It burns without intumescence, and does not evolve the odour of nitrogenous matter in combustion." Sir Walter found, however, that it was necessary to correct a statement that he made at the meeting referred to above, to the effect that in every instance that had come under his observation the caterpillar, in the living state, had descended into the ground tail foremost, his subsequent examination of specimens in his collection showing a specimen caterpillar that had evidently buried itself head foremost.

As to where this caterpillar is found, I quite agree with Sir Walter Buller as to the general distribution of the vegetable caterpillar over the whole of the North Island; and, of course, the statement made by the Rev. Mr. Taylor, as quoted above, is erroneous. I have found specimens all over the North Island except on the peninsula to the north of Auckland. Along the Bay of Plenty and in the bush country between Lichfield and Rotorua they are very plentiful. They are

common in the uplands where the soil is porous and pumiceous, as between Napier and the volcanic country, and the specimens vary remarkably in size and general appearance. They are not obtainable at all times of the year. I have gathered them at Tarawera and Te Haroto, in the bush, during October, November, and December, and they were being sold fresh and in good condition by the native children along the railway-line leading to Rotorua late in March two years ago.

The specimens vary from 1¾ in. to 3½ in. in length, and the shoots or stems vary from 3 in. to as much as 15 in. I happen to have available for reference two collections of the vegetable caterpillar, one of my own and one belonging to my friend Mr. A. Hamilton. They were collected from different districts, and a careful inspection of them seems to point to the fact that a special study of the vegetable caterpillar will provide some valuable information in the direction suggested by the late W. M. Maskell.

It is not yet known what grub it is that inhumes itself in the earth, but I do not think it is the *Hepialus*, as the segmentation is different, and the mandibles do not agree. I am endeavouring to obtain specimens of the live caterpillar from the natives, who say that it can be got at certain times of the year; but, unfortunately, it is difficult to get a native to proceed into the bush for the mere purpose of gathering a few caterpillars.

In order to show that the prevailing idea about the vegetable caterpillar is an incorrect one, I have photographed a number of specimens, each being different from the others: (1) Caterpillar with a single stem; (2) caterpillar with two stems at the same end; (3) caterpillar with bifurcated growth from the same end; (4) caterpillar with much-branched stem, like a stag's horn; (5) caterpillar with two stems united 2 in. or so from the head, followed by a bifurcation, one with and one without spines; (6) caterpillar with two stems, one at the head and one at the tail. These examples suffice to show that the caterpillar, when it inhumes itself in the ground, is affected by the spores at a different period in its movements, and there seems to me not a shadow of doubt that the caterpillar moves head foremost into the earth. I have quite a number of specimens where it is evident the fungus began to shoot as the caterpillar was head downwards, others where the caterpillar was seemingly preparing to leave the earth when the fungus began its deadly work, and absorbed the whole of the life's-blood of the caterpillar in the nourishment and maintenance of its own organism. The specimen with a shoot at either end is a proof in itself that the animal was in an almost horizontal position when it was attacked by two of

the active spores, that seemingly found a more than ordinary place for nourishment and generation.

The photographs, with the scale of inches beside the specimens, will explain the unusual length of some of the stems. It is a pity they do not show what might easily be shown by means of micro-photographs—viz., how the spores are generated. The spores, it would seem, are caught in a fold of the insect's skin in the process of inhumation, and the moisture of the earth causes the spores, or "asci," to send out a large number of filaments like a fan, and these grip the skin, just like the rata is seen to grip a matai. The skin, or chitine, is subsequently absorbed, and the fine cilia pass within the animal and are nourished by the juices which are undoubtedly kept for use by the fungus until it is wanted in the process of growth, just in the same way as a spider preserves the juices of its prey by wrapping about it a material that takes the place of the skin or integument. Thus the growth of the stem of the fungus depends for its strength and nourishment solely upon the caterpillar which it surrounds, and in a measure replaces, keeping the internal organism for the sustenance of the plant in its growth and reproduction. I have made a number of experiments with the spores, and it appears they easily generate when placed under favourable conditions.

If a few are slightly moistened in a saucer the "asci" are seen to change at a great rate. At the part where they are fixed on the stem a kind of swelling takes place, and fine cilia-like spirules are thrown out in the form of a fan. The swelling represents a gelatinous-like substance of a whitish appearance. The growth takes place at a rapid rate, and I have noticed on several occasions that, if the spores are allowed after moistening to dry, a peculiar smell is given off like that of decaying fish. I am unable to account for the cause. Sir Walter Buller says that the late Mr. Skey could discover no traces of animal matter in any of the remains of the caterpillar. By burning the hardened and shiny portions of the head, claws, and tail a most pronounced animal smell results, and this is more perceptible in the case of specimens just dug from the ground.

Possibly the caterpillars when dug from the ground vary considerably in their structure and condition, and it is certain that until the full development of the spores has taken place and the growth dies there must remain a certain part of the caterpillar's body unused. As long as there is food for the sustenance of the fungoid growth it is evident that the stem continues to grow, and this can be seen whenever an unusually large caterpillar is discovered. The stem of the plant, as shown in the illustrations, extends to as much as

15 in. in the largest specimens, and in the smallest ones the stem is only 2 in. or so.

I have made a number of experiments to discover whether the spores would germinate on other caterpillars, but have been as yet unsuccessful. I believe, however, that it will be possible to trace the effect of the growing spores upon caterpillars when inhumed under favourable conditions, and experiments are now being carried on to test whether such is possible. To me it is evident that we know nothing whatever as to the life-history of the caterpillar known as *Cordiceps robertsii.* How it lives, where it lives, under what conditions it is inhumed and attacked are all questions yet to be decided. That the caterpillar is attacked by a spore externally is evident by a mere examination of the specimens, and I am inclined to the opinion that the mycelium-like growth merely surrounds or envelopes the caterpillar, but does not absorb the juices whilst the animal is living. It is curious that the spores only appear to find a favourite locality for production on the *Cordiceps robertsii.* All the specimens I have belong to the same variety of caterpillar, and, although I can cultivate the spores, all my attempts to get them to grow on other caterpillars have up to the present time failed. But the conditions under which the caterpillars have been placed may account for the failure, and further experiments are necessary before definitely stating that the fungoid growth is special to *Cordiceps.*

In any case, the growth of a vegetable organism upon an animal, from which it obtains sustenance, is suggestive to the scientist. The forms and functions of organized life have gone back, as it were, in these latter days to the study of the lowest known organisms, and the world of intelligence has been moved at the discoveries which scientific men have made in the domain of bacteriology. I make no remark upon the wonders of this noble science beyond suggesting that the vegetable caterpillar supplies a fine illustration of a vegetable organism depending for its life and its development upon an animal; and may it not be that the bacteria which flit here and there, sometimes to destroy and sometimes to renew, act upon animal functions in a similar way, and eventually destroy that upon which they are sustained and are brought to ripeness?

Appended are photographs of the varieties of the vegetable caterpillar referred to in this paper.

EXPLANATION OF PLATE XXI.

Fig. 1. *Cordiceps robertsii.*
Fig. 2. „ asci, showing mode of growth (micro-photo.).

Art. XXXVII.—*On the Prothallium of* Phylloglossum.

By A. P. W. Thomas, M.A., F.L.S., Professor of Biology, University College, Auckland.*

Our knowledge of the development of the isosporous *Lycopodinæ* is still so incomplete that no apology seems necessary for the present preliminary statement. A special interest attaches to *Phylloglossum* since it has been recognised as a permanently embryonic form of lycopod.† *Phylloglossum* is a genus with a single species—*P. drummondii*—confined to Australia and New Zealand. The sporophyte generation is a small plant growing from a tuber, which forms a tuft of a few cylindrical tapering leaves. In fertile plants the apex of the stem forms a peduncle, terminated by a cone or strobilus of small scale-like fertile leaves.

Treub has shown that the embryo of *L. cernuum* shows a remarkable likeness to a barren plant of *Phylloglossum*, for the first formed leaves have the character of the leaves of *Phylloglossum;* hence the term "protophylls" has been given to these structures, so different from the ordinary leaves of lycopods. Further, the embryo of *L. cernuum* forms at a very early stage a tuber (protocorm), above which its protophylls rise. To this protocorm the tuber of *Phylloglossum* is apparently comparable, but in *Phylloglossum* it is not a passing embryonic structure, but is repeated annually on the formation of a new protocorm. Treub regarded the protocorm as the representative of a primitive structure originally possessed by the pteridophytes, a structure which may have served an important part in the phylogeny of the higher plants, in enabling the sporophyte to attain an existence independent of the gametophyte.

The prothallia of *Phylloglossum* have been obtained growing naturally amongst the parent plants, but it is a significant fact that in most places, even where older plants are abundant enough, no prothallia could be discovered, though many days were spent in fruitless search. In three localities only were prothallia discoverable. It appears clear that very special conditions are necessary for the germination of the spores, conditions which are not of regular annual occurrence wherever *Phylloglossum* grows. Perhaps the most important of these conditions is the presence of a fungus with which the

* Reprinted from the Proceedings of the Royal Society, London, vol. 69, p. 295, 5th December, 1901.

† Bower, Phil. Trans., 1886, p. 676.

prothallium lives symbiotically. Such a symbiotic fungus has been found in the prothallia of almost all the species of *Lycopodium* in which the development is known.

Before describing the prothallia it will be well to state that they vary remarkably in external form. Such variations as depend upon the stage of development present no difficulty, but there are other differences which are probably accidental, being due to obstacles in the soil or to the depth beneath the surface at which the prothallium commenced its development.

One of the simplest, and perhaps the youngest observed, consisted of an oval tuber below, from which rose a simple cylindrical shaft with rounded apex. Such a prothallium appears to closely correspond with the oldest prothallium of *L. cernuum* obtained in laboratory cultures by Treub. We may take the tuber, which is of constant occurrence, to correspond to the primary tubercle seen in the prothallium of *L. cernuum.*

A more advanced prothallium shows the cylindrical part of greater length and thickness, and its end slightly expanded into a crown, on which the first sexual organs appear. A little below the crown the tissues of the cylindrical body are conspicuously meristematic, especially on one side. This meristem lies below the archegonia, and its formation appears to be anticipatory of the descent of the embryo.

Older prothallia in which an embryo is already present are much more irregular in form. The crown, which may be conical, rounded, or projecting to one side, and then often shaped like the head of a horse, is commonly separated by a slight constriction from the much-enlarged part of the body of the prothallium. This latter part bears the embryo on one side; it is evidently formed by the increase of assimilatory tissues for the nutrition of the embryo. Below this swollen part the body contracts again to a cylindrical shaft, which passes downwards, to swell out again and terminate in the primary tubercle. It is this shaft which varies most; it may be long and narrow, straight or curved, or it may be shorter and stouter, or occasionally, perhaps when the primary tubercle has been formed near the surface of the ground, it may be almost obsolete. The shorter thick-set prothallia may be less than 2 mm. long; others may range up to thrice this, according to the length of the shaft. Rhizoids are produced in considerable numbers from the lower part of the prothallium, more especially from the tubercle.

The whole of the upper part of the mature prothallium is green, except the archegonial necks, but the minute chloroplasts are most abundant in the part below the crown. The cells of the shaft may contain chloroplasts, but the green colour passes away as we follow it downwards into the soil.

Sections of the prothallia show little internal differentiation of the tissues, certainly nothing which is comparable to that described in *L. complanatum* and *L. clavatum.* The cells of the tubercle appear of a rounded polygonal form. They show scanty protoplasmic contents, and appear partly exhausted. Those of the shaft are elongated; on the surface they are rectangular, in the centre they tend to become longer and more pointed. Starch is often abundantly present in the cells, especially of the central part. An endophytic fungus may be traced in the cells of the lower half of the prothallium. The hyphæ are exceedingly fine; they have been traced passing in through the rhizoids. Around the tubercle they often form a close felt, which may pass below into a strand, which suggests at first sight that the base of the tubercle passes into a root. The tubercle is commonly brownish on the surface, and the strand is a darker brown and almost opaque. But sections show that it consists of fungus hyphæ.

The prothallia are monœcious, and the archegonial necks are a conspicuous feature on the crown. On a young prothallium I have found two or three only, but on plants bearing an embryo there may be from ten to twenty. They appear to be formed in basipetal succession. In a young prothallium they may be found on the summit of the crown, but in older ones they seem to occupy a lateral position around about half the circumference. The neck of the archegonium projects from the surface of the crown as a hemisphere of colourless cells, usually in two tiers of four cells each. The venter, with the large oosphere, lies at a little depth below the surface. The antheridia can scarcely be said to show in surface views, as they lie sunk in the crown. Sections show that the antheridial cavity is elongated at right angles to the neighbouring surface. The cover-cells form a single layer. The sexual organs would seem to resemble those of *L. cernuum* more closely than those of other species of *Lycopodium.* There are no multicellular paraphyses amongst the sexual organs as in *L. selago* and *L. phlegmaria,* but on some parts of the crown the surface-cells are slightly papillose.

The thickness of the tissues renders it impossible to follow the details of the early development of the embryo, except in microtome sections. But it seems clear from the stages which have so far been examined that the development at first is much like that of the embryo in *L. cernuum.* The embryo grows obliquely downwards and outwards; the part near the archegonial venter is the foot, at the opposite end are formed the stem-apex and leaf. The first part of the embryo to appear outside the prothallium is the tip of the leaf; it breaks out at a point on the side of the thicker part of the prothallium, below the crown. A fissure extends thence

down the side of the prothallium, and the embryo appears as a short cylindrical body, bluntly pointed at both ends, placed vertically, and still connected with the prothallium by the foot, which now has a lateral position. The ends of the embryo grow downwards and upwards respectively, and at a later stage what is really the apex of the stem appears inside the lower part of the embryo—that is, the embryo immediately on escaping from the prothallium forms a protocorm, apparently in the same manner that the adult plant forms its annual tuber. The pedicel of the tuber elongates downwards until the latter is placed at a safe depth, about 3 mm., in the soil. In the meantime the leaf grows up and attains a height of 2 mm. to 5 mm. above the ground. I have not hitherto seen any formation of root during the first year of growth, the sporophyte seemingly depending largely for its supply of moisture upon the prothallium, which sometimes retains its vitality even after its crown becomes injured by drought. But sometimes, at any rate, rhizoids may be developed on the pedicel and protocorm. The leaf becomes green even before it escapes from the prothallium, and as soon as it reaches a little above the soil stomata are formed, and air passes into the intercellular spaces, whilst a slender strand of tracheids appears in the centre. The first protophyll has, in fact, exactly the structure of a small leaf as produced in later years. The further development of the sporophyte appears to be slow. By carefully dissecting out the plants in the soil one can find the remains of tubers and roots produced in former years. In many cases the plant comes up a second and a third year with only a single leaf.

It should be mentioned here that Crié has stated that he sowed the spores of *Phylloglossum* and obtained a colourless prothallium like that of *Ophioglossum*. But his statements have not been accepted, and recent writers, as Vines, Bower, Campbell, Goebel, Pritzel,* distinctly state that the development of *Phylloglossum* is not known. I have not had access to Crié's original account, and Bertrand,† who quotes Crié's statements, was unable to obtain a germination of the spores during six years' experiments. But in any case it is clear that Crié's account was incomplete, for the prothallium becomes green, and even vividly green. According to Bertrand, Crié can only have seen the tubercle which precedes the prothallium proper.

It is not improbable that the prothallium may start life as a saprophyte, aided by the endophytic fungus, and I have

* *E.g.*, Goebel, "Organographie der Pflanzen," 2te Teil, 1900, p. 439. Pritzel, in Engler and Prantl "Die Natürlichen Pflanzen-familien," Lief. 205 (1900), p. 575.

† "Archives Botaniques du Nord de la France," 1886, p. 221.

found a young prothallium which was quite colourless save for a faint yellow tinge at the upper end, as well as two others, still without sexual organs, which showed only scanty chloroplasts. It is quite probable that on the germination of the spore the tubercle is first formed, and when this is at too great a depth in the soil to receive any light it will doubtless be colourless. But I have never observed any fully developed prothallium that was not green above, whilst all prothallia which had succeeded in producing an embryo had reached the surface and attained a considerable development of chlorophyll.

A comparison of the prothallium of *Phylloglossum* with those of the few species of *Lycopodium* in which the gametophyte is known shows that it is distinctly of a Lycopod type. But, as is well known, there is a remarkable diversity amongst the prothallia of the different species of *Lycopodium*. On the whole, the prothallium of *Phylloglossum* probably resembles a prothallium of the *L. cernuum* type more closely than any other, though it is quite without the leaf-like assimilatory lobes of *L. cernuum*. Perhaps we are justified in regarding it as the simplest known type amongst the isosporous *Lycopodinæ*.

The general simplicity of the structure of the prothallium of *Phylloglossum* seems to favour the view that it is a primitive form of lycopod. It is, of course, recognised that *Phylloglossum* is a permanent embryonic form, but the simplicity of structure of the mature sporophyte does not necessarily prove that it is a primitive form of the lycopodiaceous phylum. Bower has expressed the view that *Phylloglossum* is probably a reduced form, and the absence of transitions between the simple cylindrical pointed protophylls and the scale-like sporophylls, so like those of some species of *Lycopodium*, may favour this view, if we regard these structures as homologous. Some observations which appear to be new may throw some light upon this question. Bower states that *Phylloglossum* has been seen branched. I am able to say that branching occurs in at least two distinct ways:—

1. The spike or strobilus occasionally branches; perhaps one strobilus in two thousand will be found forked, the two divisions becoming equally developed. I am, of course, only speaking of the form which grows in New Zealand, and this may possibly be a slightly more robust form than that found in Australia. The branching usually takes place above the lowest sporophyll, sometimes quite at the base of the spike, near the lowest leaf, sometimes further up, or even close to the apex of the strobilus.

But even when the strobilus forks there is no transition of form between the sporophyll and protophyll. I have occasion-

ally observed on the peduncle a leaf some distance below the rest of the strobilus, but such a leaf has always been of the sporophyll type. In the Australian form, investigated respectively by Bower and Bertrand, to whom we are indebted for most of our knowledge of *Phylloglossum*, eight was the largest number of protophylls found on a plant, whilst Bertrand urges on anatomical grounds that six is the normal number of protophylls. I have collected plants with twenty protophylls, whilst others with ten to fifteen such leaves are of common occurrence. But even in plants richest in protophylls no transition occurs between protophylls and sporophylls. So far as any evidence here available goes, it would almost seem as if the two structures were not strictly homologous.

To express my meaning in the language of a modern theory, the protophylls may have arisen from the differentiation of the lower region of a sporogonium (or the homologue of a sporogonium) in which this region had already acquired sterilised tissues, whilst the sporophylls arose from the upper fertile region of the sporogonium. If so, the protophylls cannot be regarded as sterilised sporophylls.

There appears to be no necessary connection between the number of protophylls and the reproduction by spores. Plants with two protophylls only may produce a weak spike, whilst plants of twenty protophylls may be barren.

2. In barren plants the new tuber is formed by the lowering of the apex of the stem, but in fertile plants a new outgrowth is formed, which Bower regards as adventitious. This may doubtless be considered as a form of branching. Neither Bertrand nor Bower observed more than a single tuber formed in the examples at their disposal. Bower, indeed, was inclined to infer that, as no other mode of vegetative reproduction was known, the plant depended for its multiplication solely upon the germination of the spores. But I have found that the formation of two new tubers is quite a common occurrence, though plants which form a single tuber are still in the majority. The two new tubers may be formed on opposite sides of the plant, in which case a slight dispersion of the plants takes place. Sometimes the two tubers arise close together. Apparently they may be formed almost simultaneously, or in succession. Naturally, it is the stronger plants which most frequently multiply thus, but plants of a smaller number of protophylls may branch in this way. One plant of a single protophyll was found with two tubers forming.

The occasional occurrence of branching in the strobilus might be interpreted as an indication that the ancestors of the plant were once more abundantly branched. But it

would be possible to take the opposite view, that such branching is a nascent feature, that it is a new feature in the phylogeny. Bertrand regarded *Phylloglossum* as a form reduced on account of its semi-aquatic mode of life. But it is necessary to point out that *Phylloglossum* is not a semi-aquatic; Bertrand never had the advantage of seeing the plant in its native home. *Phylloglossum*, it is true, being a very small plant, can only grow whilst the surface soil is fairly moist, hence it forms a tuber and rests during the dry season. So far as I have seen, the plant grows rather better on a hill-top; or, at any rate, it grows there at least as well as it does lower down on the slope, and I have never found it in an actual swamp. It grows well on a slope where water can never lodge. Its roots spread rather horizontally, and seldom far downwards in the ground, as though it objected to a waterlogged soil.

Whilst it is possible that evidence may yet be adduced that *Phylloglossum* in some measure owes its simplicity to reduction, there appears to be little evidence for this at present. On the other hand, it may yet prove that *Phylloglossum* is an exceedingly primitive plant, possibly the most primitive of existing pteridophytes. We have an explanation ready to hand of this exceptional retention of ancient characters—namely, the annual renewal of the embryonic stage in the formation of the protocorm. But, however this may be decided, the relatively simple character of the gametophyte and the comparison of the mature sporophyte with the embryo of *Lycopodium cernuum* are in favour of the view that *Phylloglossum* is the most primitive of existing *Lycopodinæ*.

IV.—GEOLOGY.

Art. XXXVIII.—*Notes on the Napier–Greenmeadows Road.*

By F. Hutchinson, Jun.

[*Read before the Hawke's Bay Philosophical Institute, 10th June, 1901.*]

The following rough notes on the natural history of one of our main roads are given not from any scientific value that they may have at the present time, but from a possible historic interest, as the area through which the road runs is changing rapidly from swamp and mud-flat to dry land, with a corresponding and most striking change in its living inhabitants, both plant and animal. This change is from causes both natural and artificial. The natural causes may all be summed up practically in one word—floods. From the smallest up-country freshet that just tinges the river-channel with yellow to the wild outpourings of April, 1897, each and every manifestation of the power of rain helps the spread of the dry land seaward.

It is to the work of that wild Easter-tide on this road that we may turn for a vivid illustration of reclamation, change, and renewal. Before 1897 the first section of this road that is clear of the town—that between the railway-crossing and the Tutaekuri Bridge—was bordered on each side by mud-flats covered daily by the tide. Tenanted by countless crabs and estuarine shells, a feeding-ground for gulls and curlews, its only plant-growth mats of sea-grass—*Zostera marina*—this area looked as if its time as habitable dry land was very far off. But the great flood buried the mud-flats and their denizens deep in silt, so deep that the area rose above the influence of the tide and stretched on either side a sweep of featureless sand for the rest of the winter. With the spring, however, the salt-weed, *Salicornia indica*, began to creep in from the landward edges, and a small green rush-like plant sprang up in great quantities. This latter plant was *Triglochin triandrum*. Till this visitation of 1897 it was somewhat uncommon here. Mr. Colenso, in a delightful paper on the flora of the Napier Swamp in the old days, speaks, if I remember

rightly, of finding it only along the banks of a certain creek near Clive. Another well-known botanist told the writer to look out for it under the description of "a plant like a rush, but with a fruiting-spike like a loose-headed plantain." This fits the plant exactly, and it was found shortly afterwards on the banks of the creek by the Petane Hotel. It must have been plentiful enough in some part of the region swept over by the flood, for upon large areas of flood silt it sprang up thickly, and is now almost as common a feature on the swamp and harbour shores as the salt-weed.

These two plants, *Triglochin* and *Salicornia*, are both natives: it seems fitting that these pioneers of the silt should be of our native flora. They are followed very closely by an introduction from Europe, the buckhorn plantain (*Plantago coronopus*). Like the *Triglochin*, it showed up but little till after this flood, but has since increased enormously, and is doing very good work here, being the first plant to take hold of the swamp that is useful from a stock-raiser's point of view.

The area raised above tide-level, and all its molluscan and crustacean life buried deep in silt, the gulls and curlews left it for better feeding-grounds, and it was not till a strong square-stemmed sedge sprang up thickly in the damper parts that it could boast of any bird-life save an occasional ground-lark. But now that a few species of *Mollusca* (*Potamopyrgus antipodarum*) in great numbers, and an occasional specimen of *Amphibola avellana*, have worked up the channels again, and there are pools in places deep enough for eels, one may sometimes see a bittern here, mostly on the seaward side of the road, which is much the lowest and wettest portion. Towards the New Cut, where salt-weed is the largest growth, it is very barren of higher life. But, if the crabs have vanished, their place is taken in point of numbers by land-loving relatives—the common "slater" or woodlouse, an introduced species, and a smaller native species of a marbled brown and white colour, the introduced outnumbering the native by a hundred to one. The vanished shells are represented, too, by a land species—the common grey slug of our gardens. Besides slugs and slaters, spiders and a small hymenopterous insect are fairly plentiful—a poor list after the rich water-life that lies buried under them.

We can hardly think that it ever crossed the minds of the builders of this road that their embankment would in time act as a boundary between two distinct zoological provinces. Yet from the Tutaekuri Bridge to the Wharerangi turn-off this road has been for some years practically the boundary between sea-birds, sea-shells, and sea-plants, and land-birds, fresh- and brackish-water shells, and land-plants: the sea

groups on the mud-flats and shallows of the Inner Harbour side; the land groups in the scrub and reeds and weed-choked channels that stretch away into the swamp on the other.

The mud-flats are the resort of black swan, gulls, terns, curlews, and stilts, the last four often within a short distance of the roadway; but the swan, except in the wildest weather, keeps far out of gunshot in the harbour shallows. In the low scrub of the opposite side blackbirds and thrushes chatter and whistle, starlings and mynahs wheel in flocks, with sparrows, linnets, and yellow-hammers. Besides these introduced species natives are fairly common; bitterns may often be seen during the season, hawks figure largely, with more rarely pukeko and weka, and, still more rarely, the swamp-crake.

It is interesting to note some of the typical land-birds simulating the habits of waders and fishers. I pulled up the other day to watch a large black-brown bird wading far out in the sluggish channel by the roadside, thinking it must be a rail, but it was only a hen blackbird; and I have watched larks busy in the same manner, thigh deep on the trailing strands of the weed that chokes the channel, picking off, I presume, the small shells and water-folk that swarm upon it.

The contrast between the molluscan life of either side is as marked as in the birds; in fact, from their slow mode of locomotion, still more so. Land-birds and sea-birds trespass to a certain extent on each other's ground, but the fresh- and brackish-water molluscs of the sluggish landward channel would perish as surely in the salt water of the seaward side as would the sea-shells of the tidal channel in the fresh water. It is the roadway, acting as a dam between the outgoing fresh and the incoming salt water, that has caused this sharp distinction between the inhabitants of these channels, a distinction which would be sharper still were it not for the culverts allowing a certain amount of salt water to mix with the fresh and make it brackish. This mixing adds to the interest of the landward channel, for brackish water has its own peculiar fauna and flora. The *Mollusca* of the landward channel are: *Potamopyrgus antipodarum* (common alike in fresh and brackish water); *P. cumingiani* (in Hawke's Bay found *only* in brackish water, but reported a fresh-water shell in some localities); and *P. pupoides* (found only in brackish water). The *Crustacea* consist of great numbers of sand-hoppers (*Gammarus ?*), both in and about the water, with slaters (*Oniscus*) equally abundant on the dry land. The channels and mud-flats on the harbour side have a population that must be in or about more or less pure salt water. The *Mollusca* are: *Potamides nigra* and *bicarinata*, *Cominella maculata* and *funerea*, *Monodonta æthiops*, *Amphibola avel-*

lana, *Tralia costellaris*, *Chione stutchburyi*, and *Mesodesma novæ-zelandiæ*. The *Crustacea* are: Crabs, shrimps, and sandhoppers.

These sea and salt-marsh shells are being driven gradually seaward year by year by the encroaching flood deposits. *Tralia costellaris*, a curious little member of the family *Auriculidæ*, was, before 1897, very plentiful in the salt-weed on the harbour side of the Wharerangi Road. But that flood practically exterminated it from this area; it is now very scarce, and is only found on the highest banks of the sea-creeks that run up to the road. It is plentiful enough still at the Petane end of the harbour, where I have found it climbing high on the rush-bushes after rain, reminding one that some tropical species of this family have taken to an inland and forest life as true land-shells.

The flora of the seaward side of this road is interesting only from its contrast to the opposite side. Once past the shooting-butts point, the tide swirls up almost to the roadway, leaving naked on its retreat mats of sea-grass (*Zostera*); then these harbour shallows shrink to ever-narrowing channels, which lose themselves towards the Wharerangi turn-off in silt-flats given over solely to *Salicornia* and *Triglochin*.

On the landward, or rather the swamp, side there is much more variety. We get here the typical sea-marsh flora, flourishing on the neck of comparatively dry land that divides the road from a large lagoon. The pioneers of the silt-flats nearer town, *Salicornia* and *Triglochin*, are here in abundance, with wild celery (*Apium australe*), *Samolus littoralis*, *Selliera radicans*, and *Mimulus repens*. The weed that chokes the channel is a brackish-water plant, *Ruppia maritima*.

Apium australe is the wild celery, so common alike on our coastal cliffs and sea-marshes. It is said that Cook's seamen used this plant as an antidote to scurvy. *Samolus littoralis* is of interest from being the one and only representative of the primrose family native to New Zealand. Its pale-pink flowers, which it bears in great profusion, relieves the somewhat sombre colouring of this roadside during the early months of summer. *Mimulus repens*, a curious little creeping ally of the snapdragon, is only to be seen at one place by the roadside, and that nearly opposite the Wharerangi turn-off; but it is very plentiful in other parts of the swamp, notably round the wetter portions of the paddocks of the North British Freezing-works.

The work of the flood of 1897 has been given as an example of natural reclamation. Turning to the artificial, it is interesting to watch the inroads made by man by means of draining

and cultivation. A few years ago an enterprising person fenced in a section of sea-marsh bordering the Wharerangi Road. It consisted of a desolate stretch of salt-weed bordered by pools, tenanted by just such a population as described from the seaward side of the road. It was then ploughed (it must have been wet work in many places for the horses), harrowed, and sown down in oats. These came up strong and green on the higher portions of the paddock, then reddening, lessened and failed altogether over the lower portions, nearly three-quarters of the area. Here the salt-weed sprung up refreshed, and the crabs returned to bore again in the sodden furrows. But in spite of apparent relapse the ploughing had acted beneficially for land-plants. *Cotula repens*, the "bachelor's button," sprang up thickly in the salt-weed; then on the unbroken furrows a clover (the black medick, *Medicago lupulina*) got a grip, and that pioneer of the silt the buckhorn plantain. Then it was ploughed again and sown with mangold-wurzels, with about the same result as with the oats—a fair crop inland, but dwindling outward to little yellow bulbs no larger than a radish. The second ploughing strengthened the land-plants; a sward of plantain and a feather-topped grass all but ousted the salt-weed. A third ploughing was followed by maize, which still left the outer edges to the plantain and grass, but brought in with it a wonderful collection of foreign weeds—fat-hen, Prince of Wales' feather, and others—which, now the maize is cut for green fodder, have taken full possession. The some-time marsh is now a paddock, waiting only the plough to fall into the same state as the monotonous grassy levels inland.

Beyond the Wharerangi turn-off the sea-marsh fauna and flora are soon lost in paddocks, whose alien weeds and grasses are encroaching yearly upon them. It is curious to note that here and there an ill-drained portion has, in spite of cultivation, gone back to its original salt-weed; and *Samolus littoralis* and *Selliera radicans* follow the drain-sides right up to Greenmeadows Township. But these drains have quite lost their sea-marsh fauna; crabs and sand-hoppers have given place to woodlice again, and of all the shells only *Potamopyrgus antipodarum* has survived the change to pure fresh water. It is here with its relative *P. corolla* and the limneids *Amphipeplea ampulla* and *Planorbis corinna*. These last three species are emphatically denizens of fresh water. If careful notes were taken year by year of their habitats, I think they would be found to be encroaching on the sea-marsh by water, just as the snails, slugs, woodlice, weeds, and grasses are by land. At present they are down as far as the Napier Park Racecourse, on the Greenmeadows side; at Napier they are in the swamp channel opposite the

gasworks; and they are in the Tutaekuri as low down as the mouth of the New Cut.

These rough notes are taken mainly from the point of view of a lover of shells and plants; but it would seem that this area would afford a most interesting harvest to those interested in crustacean and insect life, the crustacean life of the salt and brackish water giving place to the insect-life of the fresh, and of the insects themselves the littoral giving place to the inland species. The fauna of the New Cut gives a fair illustration of this. Where this canal joins the channel just below the recreation-ground the hand-net brings up small crabs, shrimps, sand-hoppers, and a crustacean very like a woodlouse with swimming-lobes to its tail-segments. Following up the Cut with the net, the crabs soon disappear, then the water-slater; sand-hoppers and shrimps become scarce; and as one nears the Tutaekuri the larval forms of insects come up in the net—the hideous masked nymphs of a dragon-fly, and lesser relatives, the sand and horny tubes of caddis-worms, with fresh-water shells and drowned land-shells, and the seeds of many inland plants, just such a haul as one may take from a mat of watercress in one of our upland streams.

Art. XXXIX.—*On the Volcanic Grits and Ash-beds in the Waitemata Series.*

By E. K. Mulgan, M.A.

[*Read before the Auckland Institute, 5th August, 1901.*]

Plates XXII-XXVI.

Section I.—Introduction.

The object of this paper is to describe a deposit of volcanic grit which occurs in a Tertiary formation known as the "Waitemata series." This series, of Lower Miocene age, is developed from the Auckland isthmus northwards for upwards of twenty miles, and stretches completely across the Island. The volcanic grits outcrop for the most part along the shore-line, and lie conformably between the sedimentary strata. To trace individual beds in this series is a matter of great difficulty, as these not only thin out and disappear, but are in places considerably disturbed and faulted. Fossils, moreover, occur but sparingly. The grits, however, are amongst the most distinctive beds, and in nearly all cases are fossiliferous. For these reasons they

form a valuable factor in correlating different parts of the series, and hence the importance of determining whether there are several bands of grit or only one, and whether, moreover, the material is due to air-borne or water-borne sediment. It is important also to locate as nearly as possible the position of the vents from which the material originated.

The microscopic appearance of the sections as shown in the plates will facilitate the comparison of the rocks under discussion.

SECTION II.—LITERATURE.

Dr. Von Hochstetter, in 1859, stated that beds of volcanic ashes were interstratified with the sedimentary rocks occurring on the shores of the Auckland Harbour. Subsequently, in 1864, he made the same statements, and also alluded to the remarkable blocks of volcanic rock which occur on the Whangaparaoa Peninsula interbedded with the stratified deposits.

Twenty years later, in 1879, Mr. S. H. Cox, late Assistant Geologist, reported on the country from Auckland northwards. The whole of the Waitemata series as developed round Auckland and to the north of that city he placed as equivalents of the Pareora beds and of Lower Miocene age. In his report he says, "Above these beds (Orakei Bay beds) the Parnell grit comes in interstratified with sandstone and thin beds of sandy marl; and this grit, together with a certain quantity of volcanic ash and occasional angular stones, represents the commencement of the volcanic outburst which, while some of the ash and smaller stones were spread far and wide over the sea-bottom on which the Waitemata series was deposited, attained its greatest development near the Manukau Heads, where beds of breccia at least 700 ft. and probably more in thickness may be seen resting in direct sequence on the marls, &c., of the Waitemata series, the higher beds of this series being notable for the great abundance of volcanic material which is mixed with the sand and clay. It seems probable that the volcanic activity which must have prevailed during the latter part of the deposition of the Waitemata beds, and the consequent rapid accumulation of material on the sea-bottom, may account for the great absence of animal life during the latter part of this period."

In 1881 the same writer, in a second report on the country north of Auckland, endeavours to show that the Parnell grit overlies conformably the Orakei Bay beds.

Two years later Mr. A. McKay, Assistant Geologist, wrote a brief account of the coast-line from Lake Takapuna northwards to the Wade, in which he conjectures that the volcanic ash-bed known as the "Parnell grit" is the southern

extension of the Takapuna ash-beds. He says, "Immediately north of the lake, where the sea-cliffs are higher and the rocks better exposed, they are easily identified as those underlying the Parnell grit. . . . Nearly two miles beyond the lake grey sandy marls referred to the lower beds are overlaid by a volcanic agglomerate which corresponds to the Parnell grit, differing only in the coarser material which composes it, blocks of volcanic rock more than a foot in diameter being common."

In the following year, 1884, Professor Hutton read a paper before the Philosophical Institute of Canterbury on the age of the Orakei Bay beds, in which he reviewed most of the literature bearing on the Waitemata series. He contended—(1) That there is no evidence to show that the Orakei Bay beds are older than the Parnell grit; (2) that on the whole the evidence, both stratigraphical and palæontological, is in favour of Orakei Bay beds belonging to Pareora system (Lower Miocene).

Sir James Hector, in his progress report for 1885, briefly referred to the interstratified volcanic grits in the Waitemata series. He dissented from Mr. McKay's view that the Parnell grit is the southern extension of the Takapuna ash-beds.

In 1885 Mr. James Park, F.G.S., in a report on "The North Shore to Lake Takapuna," wrote, "In the cliffs at the end of Cheltenham Beach occurs the volcanic breccia or grit seen on the coast north of Takapuna. Here it is almost identical with the Parnell grits. At Judge's Bay the strike is north-north-east, which would carry them under the tuffs at the North Head to the place indicated at Cheltenham Beach. These sandstones, although much disturbed in places, have a general dip to the west, and at the first point north of the lake are lying on a volcanic ash-bed or breccia bed containing many large angular fragments of scoriæ and lava, which appear so recent in character that when broken off it would be impossible to distinguish them from the basalts of Mount Eden."

Section III.—Sketch of Geology of District.

The rocks comprising the cliffs and shores of the Auckland Harbour fall readily under four heads, and serve to indicate as many distinct periods of geological time.

The oldest rocks of the district are the Palæozoic or Maitai slates (presumably of Carboniferous age), a compact indurated sandstone which covers considerable areas in Waiheke, Motutapu, and several other islands in the Hauraki Gulf, and is continued into the Wairoa Ranges.

Following these slates, lying, indeed, unconformably on them in places (as at Motutapu), are the Waitemata beds, of

Lower Miocene age. These consist of soft or muddy sandstones and friable shales. An average section usually shows bands of sandstone and softer shales alternating with each other. The sandstones are often hard, and vary considerably in texture from fine to coarse. In a few places they are fossiliferous, though as a rule fossils are absent from the great body of strata, though wood in fragments may occur. The strata themselves vary in thickness from a few inches to several feet, the shales or sandy clays forming, on the whole, much thinner layers than the sandstones, seldom, indeed, reaching a thickness of more than a foot. They are, moreover, much softer than the sandstones, and readily crumble away when exposed to the action either of the weather or the sea.

A noticeable feature of the series is the horizontal or gently undulating position which, on the whole, the beds maintain. Here and there, however, great disturbances have taken place, resulting in the rupture and dislocation of the strata, the formation of numerous faults, and the consequent obliteration of connecting-links between individual beds.

To the third group belong Hochstetter's Quaternary beds, consisting of plastic clays and sands, occurring, for instance, along the Tamaki Creek and on the southern shores of the Manukau Harbour.

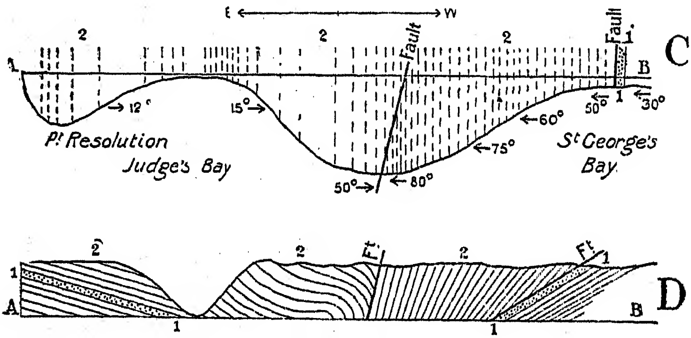
The fourth group comprises the Pleistocene lavas and tuffs which have been ejected from the numerous volcanic vents in the neighbourhood and spread over the greater portion of the isthmus. The lava, consisting entirely of basalt, varies much in texture. It is, on the whole, a hard compact rock, and is always rich in olivine. (See rock section E, Plate XXVI.)

SECTION IV.—GRIT-BEDS ON SOUTH SIDE OF THE AUCKLAND HARBOUR.

On the eastern side of Judge's Bay there occurs a band of volcanic grit some 10 ft. in thickness dipping west at an angle of about 12°. The band consists of fine volcanic material, the fragments ranging from minute specks to particles somewhat larger than a pea. The whole is firmly united together, and forms a reef which runs about 100 yards into the harbour and is exposed at low water, its hard character enabling it to withstand the action of the waves, which have worn away the softer sandstones and shales. It lies conformably between other members of the Waitemata series, is distinctly marked off from the layers both above and below, and can be traced round Point Resolution, where it forms a long outcrop on the western side of Hobson's Bay. About three miles further east, at St. Helier's Point, and again at

Tamaki Point, a similar band appears, almost identical in texture and mineral contents with that outcropping at Parnell. (In point of fact, the only difference is that the St. Helier's Bay beds are slightly coarser at the base.) To the west it appears in St. George's Bay, dipping east at an angle of 30°, the connection between the two bands being shown in section in fig. 1. Between the two exposures the sedimentary strata are much disturbed, in places being thrown on end. There seems to be little doubt that to the same band of grit can be traced the exposures at St. George's Bay, Judge's Bay, St. Helier's Point, and Tamaki Point.

Fig. 1.



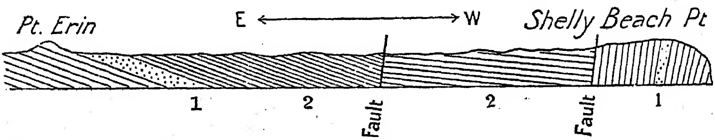
C. Plan. D. Section through AB, showing connection between outcrops of volcanic grit at Judge's and St. George's Bays, known as the "Parnell grit": 1. Volcanic grit. 2. Sandstones and shales.

Following the shores of the harbour westward, a similar band of volcanic grit is met with about a mile and a half further on below Point Acheron. The exposure occurs on the shore-line, and the band appears to dip west at an angle of 10°; but since it cannot be traced into the cliff it is impossible to estimate its thickness or be sure of its dip. Half a mile beyond this, near Point Erin, a similar band, 12 ft. in thickness, outcrops in the cliff and dips west at an angle of 17°. A few hundred yards further on, at Shelly Beach Point, it again appears, lying almost vertically between the other sedimentary strata. (See fig. 2.)

The band of grit strikes north from Shelly Beach Point and sends out a long reef into the harbour in that direction. As in the case of the Parnell grit, the strata between the outcrops are disturbed and faulted. The grit in this exposure is composed of volcanic material similar to that comprising the Parnell ash-beds.

It must be noted that both these and the Parnell ash-beds are of a fairly constant texture, and contain no large included fragments. As previously stated, the Point Acheron outcrop can only be seen as a short platform on the beach. It cannot be connected stratigraphically with the exposures at Point Erin; but the distance separating the two places is not great, and in composition the bands are identical. It seems an obvious conclusion, therefore, that the Ponsonby outcrops are connected.

Fig. 2.



Section from Point Erin to Shelly Beach Point, showing connection between the two outcrops of grit: 1. Volcanic grit. 2. Sandstones and shales.

It is impossible to correlate with certainty the Parnell ash-beds and those occurring at Point Erin, because—(*a*) A great portion of the City of Auckland is built on the land lying between them; (*b*) the intervening strata are much disturbed; (*c*) most of the intervening country is covered with tuff from some of the Pleistocene volcanic vents. But the great similarity in the material composing all these beds; the fact of there being an undoubted connection between the Parnell and St. Helier's Point outcrops on the one hand, and on the other between the various exposures at Ponsonby; and the further fact that, whereas the distance from Judge's Bay to Tamaki Point is upwards of three miles, that from St. George's Bay to Point Acheron is considerably less—would at least point towards the very great probability of the Ponsonby outcrops being extensions of those found at Parnell:—that is, the outcrops of grit occurring along the southern shores of the Auckland Harbour are merely different exposures of the same band.

SECTION V.—GRIT-BEDS ON THE NORTH SIDE OF THE AUCKLAND HARBOUR.

Across the harbour, just below Takapuna Point, at a distance of some two miles and a half from Judge's Bay, there occurs another exposure of volcanic grit. This formation, known as the "Cheltenham Beach beds," consists of a band of about 12 ft. in thickness containing both coarse and fine material. At the bottom is a layer a few inches in thickness of coarse grit or fine conglomerate, the particles being from

1 in. to 2 in. in diameter and slightly waterworn. Above this the material is finer and similar to that met with on the southern side of the harbour, at Judge's Bay and Point Erin. Through the band are scattered numerous angular or sub-angular fragments ranging up to 8 in. or more in diameter. Some of these are close and compact; others, again, are vesicular and amygdaloidal, the infiltrating mineral being principally calcite.

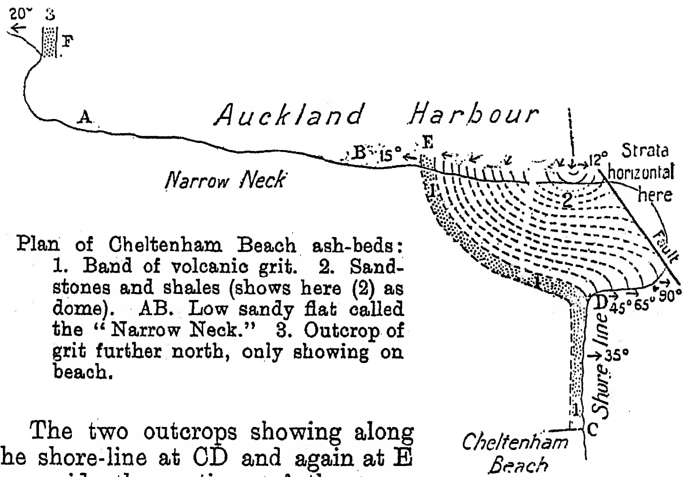
The rocks comprising the fragments are considerably altered and weathered, the feldspar crystals being many of them kaolinised. Large crystals of augite are plainly visible in most of the included fragments.

A section from one of the fragments examined under the microscope showed a microcrystalline ground-mass consisting of a triclinic feldspar, minute augite crystals, and numerous specks of magnetite, with larger porphyritic crystals of feldspar and augite, as well as those of an altered mineral. Many of the feldspars were kaolinised, and most of them contained inclusions of magnetite and augite. They were triclinic, and comprised the varieties andesine and oligoclase. Small augite crystals were numerous, but only a few were idiomorphic. The crystalline form and mode of occurrence of the altered mineral suggested the possibility of its being altered olivine. On the whole, however, the evidence was not sufficient to pronounce definitely on the constituent. The rock is obviously an augite-andesite containing perhaps a little olivine. (See rock section D, Plate XXV.; specific gravity, 2·8.)

The first outcrop of conglomerate and grit met with is at the north end of Cheltenham Beach. The band dips east at an angle of 35°, and, running nearly horizontally for about 200 yards, suddenly disappears, as shown in fig. 3. From this onwards the strata are much disturbed and faulted, in places being thrown on end. Beyond a well-marked dome a little further north the grit again appears in a band some 8 ft. or 10 ft. thick, but the thickness cannot be accurately determined as the band does not show well in the cliff. Here it dips west at an angle of about 15°, and, running out to sea, forms a long reef. From this point northwards for a few hundred yards the cliffs give place to a low sandy flat over which the sea flowed not many years ago, but which has now become dry, the land being raised partly by the wash from the hills and partly by the sand carried in by wind and sea. When the beds (Waitemata) next appear they are dipping west at an angle of 20°. Half a mile or less further north from the outcrop of grit mentioned last another exposure of the same material occurs. Here the band strikes north and presumably dips west; but, as it only shows as a

low platform on the beach, it is difficult to be sure either of the direction or the angle of the dip.

Fig. 3.



Plan of Cheltenham Beach ash-beds: 1. Band of volcanic grit. 2. Sandstones and shales (shows here (2) as dome). AB. Low sandy flat called the "Narrow Neck." 3. Outcrop of grit further north, only showing on beach.

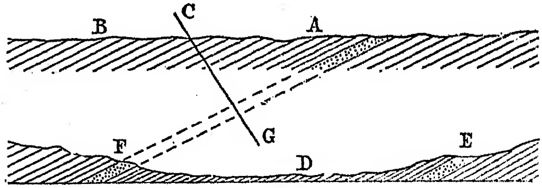
The two outcrops showing along the shore-line at CD and again at E are evidently portions of the same land as shown in above plan. This bed, dipping east at CD, has presumably had its dip changed by the same force which formed the dome, and appears again at E dipping west. The strata at the end of the point are truncated by a fault as shown. To the southern side of the point the dip rapidly increases until at the fault the strata become vertical.

In a paper read before the Auckland Institute in 1889 Mr. Park gave a plan of the Cheltenham Beach ash-beds. In this, however, no notice is taken of the change in the direction of dip in the two exposures, nor is any mention made of the dome. Both of these matters have an important bearing on the question under discussion. Furthermore, the northern outcrop is obtained by producing the line CD (fig. 3), whereas in point of fact it occurs considerably to the west of this position.

The outcrop at F (fig. 3) may have reached its present position owing to being horizontally displaced by a strike fault running east and west. The low swamp occurring between the higher cliffs on either side may well indicate some faulting of the strata, in consequence of which the sea has been able to effect an entrance and erode the narrow valley, now become a dry sandy flat. Additional force is lent to this theory by the fact that a line drawn across the narrow neck east and west would pass through low mud-flats and the waters of

Shoal Bay, and could be continued for upwards of two miles before reaching high ground. The following diagram will furnish a further explanation of this theory :—

Fig. 4.



Suppose CG to be the line of fault. Then if the downthrow occurred on side A, and subsequent denudation planed the whole surface level, the band would appear displaced at E and F as shown, the surface at D representing the low ground between the two outcrops. Furthermore, the amount of lateral displacement would increase and that of vertical displacement decrease with the angle of hade. A normal strike fault hading at a large angle would cause the necessary lateral displacement with a relatively small amount of throw.

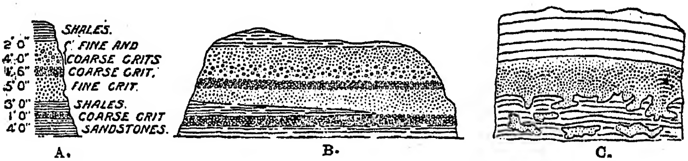
It would seem, therefore, that the exposure occurring at Cheltenham Beach, marked CD (fig. 3), is undoubtedly connected with that marked E, which is almost to a certainty the same band as the one outcropping further north at F.

Mr. Park states (page 5) that the strike of the Judge's Bay bed would carry it to Cheltenham Beach. This may be so, but the bed at Judge's Bay dips west, whereas that at Cheltenham Beach dips east. Besides, the strata at Cheltenham Beach are so disturbed as to render their correlation with those occurring at Parnell a matter of extreme difficulty; indeed, no stratigraphical connection can be established between the beds on the opposite sides of the harbour. Considerable difference, moreover, is to be found in the material composing the beds at the two localities. At Parnell the deposit shows plenty of Maitai slate, contains no larger fragments and extremely few fossils; whereas at Cheltenham Beach the grit is coarser in character, in places merging into conglomerate, is distinguished by numerous blocks of andesite, and is fossiliferous throughout.

From Cheltenham Beach north the strata consist of the ordinary sandstones and shales, these being overlaid at Takapuna Beach by a stream of basaltic lava from the old crater which is now occupied by Lake Takapuna. About a mile north of this crater-lake the ash-beds again appear in the sea-cliffs, lying, as before, conformably between other beds of the

Waitemata series. At this point, however, they present the curious appearance indicated by the accompanying section (fig. 5). Portions of the volcanic grit outcrop in irregular patches and detached bands on the weathered surface of the cliff in such a way as to suggest at first sight a number of different layers. After a careful investigation of the locality, I am of opinion that only one bed is to be seen, and that the appearance of different bands has resulted from portions of the grit being squeezed in between the softer sandstones and shales. The appearance has been produced subsequent to deposit. This belief is further strengthened by the fact that in places the shales between the grit are arranged in lenticular masses, thinning out and disappearing in the course of 50 or 60 yards or even less.

Fig. 5.



Appearance of cliff: A. Layers of grit apparently separated by sandstones and shales. B. Grit continuous. Sandstones and shales thinning out. C. Grit appearing in detached masses through softer strata.

The grit here presents much the same appearance as that at Parnell and Point Erin, except that in places there are coarser layers with fragments up to $\frac{3}{4}$ in. in diameter. Scattered through the ash-beds are angular and subangular volcanic fragments, some of them being upwards of 12 in. in diameter. These consist of a vesicular lava of augite-andesite showing large augite crystals and numerous amygdules of calcite and the zeolite chabazite. A section made from one of these blocks showed under the microscope a microcrystalline ground-mass similar to that seen in the Cheltenham Beach section, except that a good deal of it was composed of an altered product—probably chlorite. As in the case of the other section, the porphyritic constituent consisted of large crystals of andesine, oligoclase, and augite, and a small amount of altered olivine. The feldspars showed broad as well as fine lamellæ, and contained numerous inclusions of augite and magnetite. In some of the crystals the curious phenomenon appeared of the direction of extinction being different in different parts of the crystal. The edges and central portions extinguished at different angles, owing to the outer zone being less basic in character. Large and small augite crystals were numerous, and many of the former showed well-marked crystalline form. Specific gravity, 2·7.

The rock, it will be seen, is similar in all essentials to that found at Takapuna. (See rock section A, Plate XXII.)

Note.—The large crystal shown in the section was the only undoubted olivine crystal present. Without this explanation the section would seem to belong to a rock rich in olivine. This is not the case.

The only description of the included fragments of rock in these deposits is that given by Mr. Park, who states that the rock composing the included fragments could not be distinguished from Mount Eden basalt. It is important to distinguish at the outset between the megascopic characteristics of the two rocks. The Mount Eden lava is a well-defined basalt, rich in olivine, whereas the rock included in the deposit of grit is an undoubted augite-andesite. In some of the fragments from Takapuna ash-beds a very few olivine crystals do occur, but they are much altered, and can only be identified by the aid of the microscope.

The rocks in the neighbourhood of the grit are much contorted and disturbed. Indeed, this disturbance seems to characterize most of the sedimentary rocks in the immediate vicinity of the volcanic grits.

The ash-beds here reach a thickness of from 10 ft. to 14 ft., and can be traced for about 100 yards north. They dip landwards, or towards the west, at an angle of 15°, and show just before disappearing in the cliff an outcrop approximately horizontal. Fine and coarse grits seem to be associated without any obvious method of arrangement, shading into one another without any distinct lines of demarcation. The particles vary from the finest material up to angular or subangular fragments 2 in. in diameter. The sandstones and shales here and there thin out and disappear, and the grit shows the irregular arrangement mentioned previously. This thinning-out of the strata is probably another indication of the pressure to which the beds have been subjected. Fossils are here relatively abundant as compared to Cheltenham Beach.

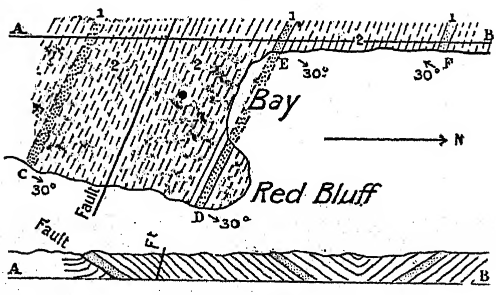
Both Mr. McKay (*l.c.*) and Mr. Park (*l.c.*) assert that these ash-beds are portions of the band seen at Cheltenham Beach. But no stratigraphical proofs in support of this contention are attempted; in point of fact, none are available. The Waitemata beds are obviously shallow-water deposits. None of the strata as a rule persist for any great distance. Hence the difficulty of establishing any stratigraphical connection between outcrops separated from each other by a distance of from three to four miles. The probability is, however, that such a connection does exist.

About a mile further along the beach, at a place called Red Bluff—the headland being stained by red and brown oxide of iron, suggestive of its volcanic origin—the volcanic grits

again appear in a band about 12 ft. in thickness, and can be traced northwards for a few hundred yards. Between the exposures of grit just described and those at the Red Bluff the sedimentary strata are considerably disturbed and faulted, so much so that it is almost impossible to establish any satisfactory connection between them. It is a noteworthy fact, however, that nowhere do these volcanic ash-beds show more than one outcrop—*i.e.*, nowhere do they outcrop as a number of bands distinctly separated by sedimentary strata.

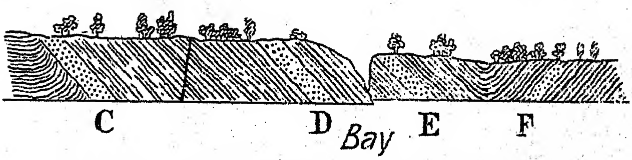
At the Red Bluff the grits become coarser, in some places passing into conglomerates, with fragments, slightly waterworn, 2 in. to 4 in. in diameter. The coarser texture of the beds in this neighbourhood would seem to indicate greater proximity to the old seat of activity. Scattered through the beds are large volcanic blocks corresponding in size, texture, and composition to those previously described; and, as in the case of similar exposures elsewhere, these ash-beds lie conformably between the Waitemata sandstones and shales. Here, however, the direction of dip is north-east, and the angle at which the beds are inclined approximately 30°.

Fig. 6.



Section through AB.

Plan and section showing connection between outcrops of volcanic grit at the Red Bluff: 1. Bands of volcanic grit. 2. Sandstones and shales. C, D, E, F. Four outcrops of grit.



Sketch showing four outcrops of grit at C, D, E, and F, as actually seen on the ground.

The two outcrops at the Red Bluff, C and D, are caused by a fault which has parted the band and displaced one portion horizontally (see section). Beyond outcrop D the band disappears in a little bay, but reappears again a short distance further on at E, where it has been bent into a syncline showing as a fourth outcrop at F. These are the only exposures of the grit in this locality. As in the case of the Takapuna ash-beds, they are fossiliferous throughout.

That these ash-beds were laid down in water is abundantly proved by the included fossils (*Bryozoa*) they contain. The angular character of the whole of the material, both large and small, would point to its being deposited at no great distance from where it originally fell; whilst the fact that the bands lie conformably between the other members of the Waitemata series tends to indicate that these grits were laid down horizontally and subsequently tilted by the same forces which caused the inclination of the other sedimentary beds.

As already mentioned, these grits in several places are fossiliferous. Indeed, the fossils are abundant and can be readily seen standing out from the weathered surface. In the softer strata above and below they hardly occur at all, the gritty floor having been evidently more favourable for their growth, and the calcareous nature of the grit having aided in their preservation. Mr. S. H. Cox says that these deposits of grit represent the commencement of the volcanic outbursts which culminated in the formation of the volcanic breccia at the north Manukau Head, and further adds that this volcanic activity may account for the great absence of life during the latter part of this period. This explanation, however, does not seem satisfactory, since it is in the volcanic beds that fossils are most numerous; whilst, moreover, many of the *Polyzoa* and *Bryozoa* occur in the positions they occupied whilst living.

This brings us to a consideration of how the material reached its present position. It is hardly conceivable that it was ejected into the air and fell as the product of a single shower, for in that case one would expect to find the fossils either at the top or bottom of the beds—possibly in both places—whereas some, at any rate, of the exposures are fossiliferous throughout their entire thickness. The more probable explanation is that the material was furnished gradually, and carried along the bottom by currents working out from the sources of supply. In this way a large amount of volcanic material could be spread over the bottom with sufficient slowness to admit of the growth of marine organisms, yet rapidly enough to mark off the deposit from other members of the series.

SECTION VI.—GRIT-BEDS OF THE WHANGAPARAOA PENINSULA.

The next important outcrops of these volcanic grits are on the Whangaparaoa Peninsula, where they occur in considerable numbers and exhibit great variety of texture. As elsewhere, they lie here conformably between the other members of the series, which have been much disturbed in their vicinity.

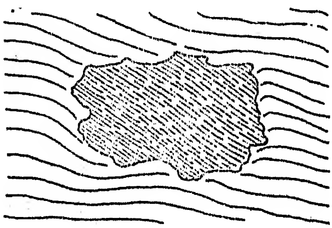
Starting from the northern side and travelling east, the ash-beds are first met with in a place called Coal-mine Bay. Here the grit occurs as a well-marked band dipping north at an angle of 8°. In composition and appearance this bed corresponds with those described previously, being perhaps, on the whole, a little coarser in texture. It varies from fine to coarse, the coarser material being below, shading into a fine conglomerate. The exposure at this place is not large, but about half a mile further on the same band outcrops again and forms a reef running for some distance into the sea. The included blocks, which are numerous, consist of a hard, compact, fresh-looking andesite, with large porphyritic crystals of augite and a triclinic feldspar. Examined microscopically a section from one of these blocks showed a ground-mass and porphyritic constituents almost identical with those already described. The feldspars comprise the varieties andesine and oligoclase, and, as in the other sections, show numerous inclusions of augite and magnetite. The augite crystals are perhaps larger than those in the other rocks described, whilst the olivine, although showing crystalline form, is much altered, and is not present in sufficient quantities to form an essential constituent. Chlorite, evidently an alteration product, occurs in several places in abundance. (Specific gravity, 2·8.)

From Coal-mine Bay east the grits and fine conglomerates are numerous, cropping out at intervals all along the coast. They are similar in appearance to the one just described, except that they become distinctly coarser towards the point to the east The beds here have been so disturbed and the exposures in places are so small that it is impossible to establish any stratigraphical connection between individual outcrops. In both grits and conglomerates fossils occur from top to bottom. The included fragments here reach a diameter of from 1 ft. 6 in. to 2 ft., and occur in greater abundance than in the grits nearer Auckland.

Towards the end of the point great blocks of andesite appear, measuring in one case at least 18 ft. across. This huge mass must have fallen on the bottom and been covered up with sediment. The force with which the mass fell may have displaced the strata, causing the appearance presented in the figure in the margin. It may, moreover, have fallen in water.

But the strata round and about the block are considerably weathered, one bed shading into another without any clear line of division, hence the difficulty of explaining satisfactorily what has actually taken place.

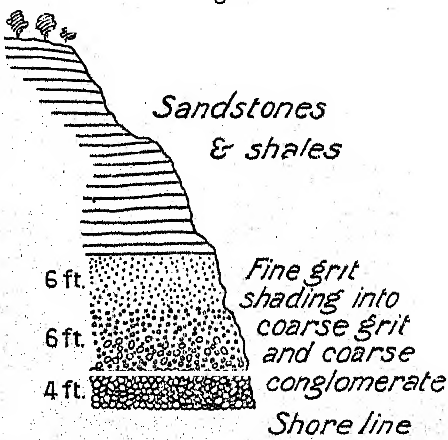
Fig. 7.



Included block of andesite, 18 ft. across, imbedded in sandstone and shale at Whangaparaoa.

In the case of other included masses the beds do not seem to be in any way displaced, and in no case has any alteration in the sedimentary strata been brought about at their junction with these masses. This phenomenon is not easily explained. The rocks are not in the least dyke-like in character. They have effected no alteration in the surrounding beds. They cannot, therefore, be explained as being the remains of intrusive masses. They must have reached their present position when cool, and cannot have fallen with much violence on the soft yielding sandstones and shales, which otherwise would show more signs of being displaced. Moreover, such huge masses cannot have been hurled for any great distance through the air, and the fact that they are not waterworn forbids the assumption that they have been transported far by the action of water; and yet there is no indication of any volcanic vent in their neighbourhood further than that furnished by the presence of the blocks themselves. It may have been that they were deposited quietly on a relatively hard firm bottom and subsequently covered with sediment.

Fig. 8.



Section at end of point, Whangaparaoa.

At the extreme eastern point of the peninsula is a series of volcanic deposits some 16 ft. in thickness, with horizontal

outcrop, as shown in accompanying sketch. Below is a coarse conglomerate, merging into breccia, containing subangular fragments up to 3 ft. in diameter, none of the blocks being much waterworn. Above, the conglomerate gradually becomes finer, passing into coarse and then into fine grit, the whole being capped by sandstones and shales. Throughout the grit angular volcanic fragments up to 1 ft. in diameter are scattered, and the whole, as elsewhere, is fossiliferous.

The rock of which these blocks are composed is hard and compact, with very large augite crystals and crystals of feldspar showing plainly. Under the microscope the rock appeared to be identical with that found at Coal-mine Bay, except, perhaps, that the ground-mass was almost holocrystalline and the olivine more difficult to identify.

From the presence of such large masses of volcanic rock it would appear that the vent from which they were discharged was somewhere in the immediate neighbourhood, though I could find nothing to show in what direction it was likely to be discovered. Possibly its site may be further north or east beneath the waters of the Hauraki Gulf.

On the southern shores of Whangaparaoa similar bands of grit occur at intervals, but the outcrops are not so well marked as those on the northern side, and the material of which they consist is finer than that met with on the opposite shore. There is little doubt that these outcrops are merely the southern extension of those found on the northern side of the peninsula.

SECTION VII.—GRIT-BEDS OF THE MANUKAU HARBOUR.

Along the northern shores of the Manukau Harbour there occur numerous outcrops of volcanic grit, both fine and coarse deposits being abundant. In several places connection can be traced between the outcrops, but more frequently this is not possible. There is, however, with one exception, to be mentioned presently, absolutely no evidence to show that the bands are distinct.

The same formation prevails here as that found along the shores of the Auckland Harbour, and in every case the grit lies conformably between the sandstones and shales of the Waitemata series. In many places the strata show evidence of having been subjected to much disturbance, and faulting is common all along the coast-line.

The first outcrop of grit appears on the beach about a quarter of a mile from the Village of Onehunga. It consists of angular fragments ranging from very fine particles to those the size of a pea, but in this place the outcrop is so weathered that it is difficult to determine its composition. It here disappears underneath the shore-line.

A few hundred yards further on a similar band outcrops, having at its base a layer of fine conglomerate (the particles being about 2 in. in diameter) some 3 ft. in thickness.

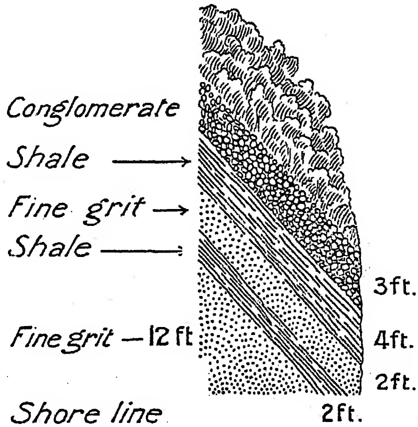
A quarter of a mile west of this spot another exposure occurs, distinctly coarser than that first met with. The whole band, about 10 ft. thick, is composed of fragments of scoriæ and volcanic ash up to $\frac{3}{4}$ in. in diameter, and contains a great deal of wood in minute pieces converted into lignite. This bed can be traced for some distance, but finally disappears in the cliff. It reappears, however, half a mile further on, maintaining the same thickness and texture. Scattered through the band at this spot are a considerable number of angular volcanic fragments, many of them being 1 ft. or more in diameter. They are imbedded in the grit, and seem to have been thrown out when that material was deposited. The rock is a hard fresh-looking andesite, with minute steam-cavities, showing microscopic crystals of augite and feldspar. (Rock section C, Plate XXIV.)

Examined microscopically an average section showed a microcrystalline ground-mass similar to that appearing in the other sections described, though containing perhaps a little more feldspar. The porphyritic constituents were identical with those in the other sections, except for the absence of olivine, no traces of which were to be found. In some of the feldspars appeared the same peculiarity as that seen in the section from the Takapuna ash-beds, successive zones of the material of the crystals extinguishing at different angles. Augite and magnetite were very plentiful, the former appearing in both large and small crystals, and showing well-marked crystalline form. (Specific gravity, 2·7.)

From this on westwards for a couple of miles there are frequent outcrops of these ash-beds. In several places they contain large angular included fragments similar to those just described. Here and there they pass into conglomerates whose particles are in some cases considerably waterworn. The conglomerates for the most part, when traced upwards, pass into finer grits. The coarser portions do not contain fossils. In some of these conglomerate beds I found pebbles of Maitai slate. These, about 1 in. in length, were flattened and much more waterworn than the volcanic material. None of this slate has yet been found nearer than Motutapu, an island in the Hauraki Gulf about five miles north-east of Auckland. The inference is that these pebbles have either been derived from beds of slate in the immediate neighbourhood underlying the Waitemata series, or they have been brought into their present position by the agency of rivers or currents, which have carried them from more distant localities.

After passing this spot, about a mile beyond a headland called "The Horn," the outcrops of grit disappear, and are not met with until about five miles further on, when they again become plentiful. They are similar in every respect to those already described. One exposure, however, deserves special mention. It occurs at Shag Point. As shown in sketch (fig. 9), this consists of a band of conglomerate composed of fragments of a close-grained andesite, 6 in. to 8 in. in diameter, much waterworn and rounded. This bed, 3 ft. in thickness, rests on beds of shale some 4 ft. thick; and this, again, is underlaid by a layer of grit 2 ft. in thickness. A small layer of shale separates this from another band of grit 12 ft. thick, which extends to and passes under the shore-line. The strata here dip into the hill and disappear. To the west the coast-line curves round to form a bay, whilst to the east the cliffs give place to a low gently sloping bank covered with vegetation; hence this is the only section available. Above, the vegetation extends down to the conglomerate and the rocks are completely decomposed, so that it is impossible to say what may overlie the band—most probably the ordinary Waitemata sandstones and shales. It would appear from the section that there are at least two, and possibly three, distinct bands, one of conglomerate and two of grit, separated by layers of shale. This conjecture is rendered all the more probable from the fact that the conglomerate overlies the grit. Here, however, we are approaching a country where in early Tertiary times there was great volcanic activity; hence it is not surprising to find an increase in the amount of volcanic material interstratified with the ordinary sedimentary deposits.

Fig. 9.



Sketch at Shag Point, showing distinct bands of conglomerate and grit.

The country from Puponga Point northwards consists of coarse volcanic conglomerate intersected by dykes and lava-streams of andesite and beds of volcanic tuff. Masses of Waitemata beds occur in places mingled with the conglomer-

ate, as though the volcanic explosions of former times burst through and ruptured the sedimentary strata, fragments of which were eventually enclosed with the conglomerate.

The lava-streams of this district are, on the whole, very much alike. They consist of a hard compact rock slightly vesicular, showing abundant augite and feldspar crystals. The augite is plentiful, but none of it is very large. I have examined a considerable number of rock sections from these lava-flows, and have found the rocks similar—indeed, almost identical—with those already described from the fragments in the volcanic grits. They differ from these only in the absence of olivine; but, as this mineral is not an essential constituent, its presence or absence is a matter of but small importance.

Section VIII.—Summary and Conclusion.

It will be seen from the foregoing that these volcanic grits are spread over a considerable area on both sides of the Auckland isthmus, and that they invariably lie conformably between the sandstones and shales comprising the Waitemata series. It is clear, moreover, that the material, although arranged by water, has not been brought from any great distance; at least, the larger fragments could not have been carried far. A careful comparison of the sections described—and these, it must be remembered, were taken from exposures separated by considerable distances—shows that the rocks differ only in the presence or absence of olivine, and that this difference is one not between separate exposures on the same side of the isthmus, but between those on opposite sides. Moreover, this difference is so slight that it hardly deserves to be considered at all, the rocks being identical in all essential mineral contents and in specific gravity.

Stratigraphically there is no evidence to show that all the outcrops belong to one and the same band; but the close correspondence between the fragments of rock included in them, their similarity in texture, in bedding, in arrangement, and in fossil contents, and, further, the fact that in no case, except at Shag Point, is there any exposure showing more than one band, whereas in several cases a connection can be traced between separate outcrops, all furnish evidence which points towards the probability of the various exposures being connected together. There seems little doubt that this is the case with the exposures on the southern side of the Auckland Harbour. Between the ash-beds at Cheltenham Beach, Takapuna, and Red Bluff the connection has not been established; but the great similarity presented by these exposures, and the fact that the several outcrops showing at Cheltenham Beach can be correlated, as can also those ap

pearing at Red Bluff, adds considerably to the likelihood of a single band being accountable for the whole of the exposures along the northern shores of the harbour, perhaps—though this is not so certain—as far as Whangaparaoa Peninsula. If this be the case, and there seems to be much evidence in support of the contention—that is, if a band of grit maintaining an average thickness of 10 ft. or 12 ft. persists for upwards of six miles in a northerly direction—the inference does not seem an extravagant one that the same band, which, it is to be borne in mind, shows no signs anywhere of thinning out, should extend two or three miles towards the south. This distance would bring it across the water as far as Judge's Bay, and so connect the exposures on the opposite sides of the harbour. This, however, is only a conjecture, though by no means an unreasonable one.

In a previous portion of the paper I referred to Mr. Park's statement that the strike of the grit at Judge's Bay would carry it to Cheltenham Beach, a statement which in itself is perfectly correct, but which does not meet the difficulty of correlating the two exposures. Though there is much in favour of the contention, and though it is possible to imagine conditions under which the existing outcrops could be connected, yet the presence of large masses of lava in one set of beds and their entire absence in the other is not easily accounted for. The whole matter, in short, is one whose solution is beset with considerable difficulty. It was this I wished to bring out in referring to Mr. Park's statement.

From the evidence adduced it would appear, so far as the northern side of the isthmus is concerned, that we may conclude the exposures on the southern side of the harbour to be connected; that a very strong probability exists of the Cheltenham Beach, Takapuna, and Red Bluff outcrops being connected; and that there is much to be said in favour of the theory that the Cheltenham Beach and Parnell exposures belong to the same band.

Along the shores of the Manukau Harbour the beds may not correspond to those met with on the opposite side. There are no exposures on the land between the two seas, and the distance as the crow flies from the Parnell ash-beds to those nearest to Onehunga is about six miles, hence the impossibility of connecting the two stratigraphically. But, whether connected or not, these beds are identical with those found on the opposite side, and, like them, have every appearance of belonging to the same band. The outcrop at Shag Point, near Puponga, showing the separate beds, is certainly an exception; but it must be remembered the exposure was not large, and no very definite conclusions need be based on it. It may be that the lower layer of grit is a western extension of that

found nearer Onehunga, and the interbedded shales merely lenticular masses between which the grit has been squeezed, the thinning-out being obscured by the formation of the ground and the vegetation covering it. In this case the conglomerate at the top would represent a later deposit. But the presence of conglomerate on the outskirts of a conglomerate country is not surprising.

From the similarity between the fragments included in the grits and the composition of the grits themselves it is not unreasonable to conclude that they were ejected by vents which had some connection with each other. Moreover, that there were several vents there is not the slightest doubt. It is quite inconceivable that fragments of rock such as those found at Whangaparaoa, Takapuna, Cheltenham Beach, and in the ash-beds along the northern shores of the Manukau Harbour, could have been hurled for any great distance through the air; and the fact that they are not much water-worn shows that they have not been transported far by the agency of water. Hence we may conclude that there were several centres of eruption and several showers of ashes, some coarser than others, as in several places, notably at Takapuna (see Section V., above), the coarser ash overlies the fine. Moreover, the eruptions which caused the ash must have occurred about the same time, and the showers themselves must have taken place at relatively short intervals.

All traces of the localities of these old centres of activity have long since disappeared; but the evidence furnished by the material composing the grit enables within certain limits the loci of some of them to be established. One volcanic centre undoubtedly existed at or near Whangaparaoa. Such huge fragments as those found there must certainly have been derived from a vent in the immediate vicinity of their present position. Another centre evidently lay not far from the Takapuna ash-beds, the fragments in the grits there being too large to have been derived from Whangaparaoa, a distance of about ten miles. Another vent probably had its site at or near Cheltenham Beach. But in the case of the two latter it is not possible to do more than conjecture. It may have been that a single vent situated somewhere between them furnished the material for the deposits in both places, as well as that for those on the southern shores of the harbour. That it probably existed nearer to Takapuna and Cheltenham Beach than to the southern side of the harbour is shown by the difference in texture of the material in these places, that found in the beds of the former being much coarser than the other. There is, however, nothing to indicate either the precise locality or the number of these vents. It is quite conceivable that much of the material was derived from vents in the

country now occupied by the andesitic ranges of Waitakerei. The Parnell grit may well have had its origin there, and have been brought down by rivers and currents operating at a time when the physical features of the district were altogether different. But the whole question, either of locating precisely these old vents or of estimating with certainty their probable number, is one which offers but a feeble chance of ever being satisfactorily solved.

Note.—The Waitemata series can be traced further north than Whangaparaoa, good sections showing along the cliffs at Waiwera and round the Mahurangi Harbour, where the volcanic grits again appear. North of this the sedimentary rocks change considerably in character, the numerous layers which distinguish the sandstones on the Auckland isthmus giving place to thicker bands of a more highly indurated sedimentary rock darker in colour and closer in texture. The grits at Waiwera and Mahurangi are very similar both in appearance and texture to those already described, and, like these, contain numerous angular and subangular fragments of augite-andesite, some of which reach upwards of 1 ft. in diameter. Their mode of occurrence, however, does not throw any additional light on the questions raised in this paper.

ART. XL.—*Notes on some Andesites from Thames Goldfield.*

By Professor JAMES PARK, F.G.S., Director, Otago University School of Mines.

[*Read before the Otago Institute, 12th November, 1901.*]

HORNBLENDE-ANDESITE.

FROM the Mata Stream southward the deeply eroded surface of the crumbling Palæozoic slaty shales, which form the basement rocks of the Hauraki Peninsula, are covered with a great pile of andesite lavas, tuffs, and breccias. From the Mata northward the coast-line is occupied by the slaty shales for a distance of eight or nine miles without interruption. Between the Mata and Waikawau Streams the slaty shales are intruded by seven massive dykes of igneous rock which are well exposed in the deep road-cuttings winding around the indentations of the rocky shore-line. The general trend of the dykes is east and west, but, so far as I could discover, they do not appear to reach the valley of the Waikawau, which runs parallel with the coast-line for some

two miles, at a distance varying from half a mile to a little over a mile; nor do they crop out on the ridge separating the Waikawau Valley from the sea. These circumstances would tend to show that the portions of the dyke-like masses now exposed in the sea-cliffs and road-cuttings are the original summits of igneous intrusions uncovered by comparatively recent marine erosion. The contact-line between the slaty shales and dykes is clearly exposed in a number of places, but in all cases the degree of alteration of the clastic rock is singularly little. In the immediate vicinity of each dyke the slaty rocks are generally bent and shattered and the joints much slickensided, as if the intrusions of the igneous mass had exerted sufficient pressure to cause local thrust accompanied by shearing and displacement, more especially along the planes of bedding. At the actual line of contact the shales are merely hardened, or sometimes brecciated for a depth of an inch or two. On many surfaces no alteration is perceptible.

In my memoir on the "Geology and Veins of the Hauraki Goldfields"* I described these rocks as hypersthene-augite-andesite, from the petrological description and name supplied by the late Professor Ulrich.† A subsequent visit to the locality convinced me that an error had arisen, probably through a misplacement or exchange of a label, and in January of this year I made a further examination of these dykes, at the same time collecting examples of each for more detailed investigation. As a result of microscopic examination in thin sections I find that these intrusive masses are composed of hornblende-andesite. There is no evidence obtainable in the field to fix the date of their eruption even approximately; but, judging from the fact that they occur as dykes penetrating the basement rock, and that no hornblende-andesite, so far as ascertained at present, is known to occur associated with the gold-bearing andesitic volcanic rocks which everywhere overlie the slaty shales, it is perhaps only reasonable to infer that they are at least older than the gold-bearing andesites. All the dykes are much decomposed, making it difficult to obtain good examples for microscopic study.

Dyke No. 1.—This forms the first rocky bluff, some 30 chains south of the mouth of Waikawau River. It shows an apparent width of about 240 yards. It is a dark-grey compact rock; feels somewhat rough to the touch. Hand samples show conspicuous crystals of feldspar and hornblende, the former up to 0·5 cm. and the latter 1 cm. long. In polarised light the base is clear and crowded with feldspar

* Trans. N.Z. Inst. Mining ngineers, 1897, vol. i., p. 81.
† *l.c.*, p. 26.

microlites and thinly dusted with magnetite, which also occurs in occasional large irregular aggregates. The feldspars are plagioclase, translucent, often much clouded with glass inclusions; not often well developed; larger phenocrysts zoned with inclusions and not much twinned; extinction angles large, indicating a basic variety, probably labradorite. Some large plates show no twinning, but exhibit a zoned structure due apparently to a succession of isomorphous layers of growth. A little sanidine is present. The hornblende is generally altered; often shows black resorption border; interior changed to serpentinous matter showing bright polarisation colours; strongly pleochroic, changing from pale yellowish-brown to greenish-brown. Calcite abundant. With dilute hydrochloric acid brisk effervescence takes place around feldspars and hornblendes.

Dyke No. 2.—This occurs about a quarter of a mile further south. It runs east and west, and shows a width of about 300 ft. It is a compact dark greenish-grey rock. Shows crystals of feldspar and hornblende plainly to unaided eye, but not conspicuously. Under the microscope the ground-mass, or base, is very abundant, clear, and finely dusted with magnetite. The feldspars are zoned with glass inclusions; in other parts clear and fresh. The inclusions are arranged round the periphery of the crystals, following the crystallographic planes, and also as irregular aggregates along cracks. A little sanidine is present. The hornblendes are mostly altered to serpentinous matter, but do not show resorption borders. Prismatic forms common. Pleochroism: $\alpha =$ light-brown; β and $\gamma =$ dark bluish-green.

Dyke No. 3.—This occurs about eight chains further south. Its greatest extension appears to be parallel with the coast. It throws out many ramifying branches through the slaty shales; extends along the beach for nearly 350 yards. This is a dark greenish-grey rock, closely resembling No. 2 in hand samples. Ground-mass clear; not abundant; crowded with feldspar and other mineral microlites. Feldspars mostly clear, well-twinned, showing brilliant polarisation colours; inclusions numerous. A few large idiomorphic plates present in each section. A little sanidine present. Hornblendes are all much altered; outlined with black borders; centre clear or crowded with decomposition products. Calcite and a little secondary quartz present. A section cut from a sample of this dyke, obtained near southern point of contact with slaty rocks, contains nothing very marked to distinguish it from the section described above, except the condition of the hornblendes, which is less altered, being often quite fresh.

Dyke No. 4.—This occurs about 45 yards further south. It extends along the beach for some 170 yards. A dark

greenish-grey rock crowded with crystals of feldspar and hornblende just discernible to the unaided eye, and imparting a rough impression to the touch. Base clear; not abundant, but, like No. 3 dyke, crowded with microlites and crystals of feldspar and hornblende. Feldspars fresh, but often clouded with inclusions; zonally arranged. Not much twinned. Hornblendes generally altered. Calcite and secondary quartz present. Iron not abundant, except as fine dust in base and around hornblendes.

Dyke No. 5.—This begins about 400 yards further south. It trends east and west, and shows a width of about 125 ft. This rock is much altered. Colour on surface pale bluish-grey speckled with chlorite, imparting porphyritic appearance. Ground-mass clear. In polarised light presents a finely granular appearance, due to presence of grey microlites of fairly uniform size.

Feldspar phenocrysts not numerous; mostly fresh, and not much twinned. Slides contain isolated crowded aggregates of small plagioclase crystals, not much twinned, but fresh, and showing bright polarisation colours. The hornblendes are mostly altered to chlorite or replaced by magnetite. All are bordered with magnetite.

Dyke No. 6.—This occurs 330 yards south of No. 5. It has an exposure about 400 yards long. A very dense blackish-green rock, with conspicuous crystals of feldspar. When wet almost dense black. Ground-mass abundant, dark bluish-grey, in places almost black, from presence of clouds of iron-dust. Feldspars plagioclase, not abundant; occur only as large idiomorphic plates, not much twinned; fairly fresh and clear. The hornblendes are completely altered to serpentinous matter. Their original crystalline forms are sharply outlined by narrow, but very even, distinct black borders of magnetite. Parts of interior often occupied by clear matter. A little calcite and hæmatite are present.

Dyke No. 7.—This begins about 300 yards further south, and thence extends to Mata Stream. It is a greenish-grey rock, much decomposed near the surface; feels rough to touch; shows crystals of feldspar and hornblende, imparting a granular appearance to rock. Base clear, but not abundant; crowded with microlites and plates of feldspar and hornblende. Feldspars fresh, but not very clear, from presence of inclusions; mostly well-twinned plagioclase. Extinction angles indicate basic variety. A little sanidine present.

Hornblende occurs both fresh and changed to chlorite and serpentinous matter; some plates show black resorption borders. Apatite present; iron fairly abundant.

In a paper read before the Australasian Association for the Advancement of Science Captain Hutton, F.R.S., describes a

similar hornblende-andesite from a dyke on the shore a little north of the mouth of Tapu Creek, which evidently refers to the dyke at the mouth of the Mata Stream.*

AUGITE-ANDESITE.

A very dense compact blackish-green, almost black, rock cropping out on coast between McCormick's farm and Puru Flat, about four miles and a half north of Thames. Base abundant; grey-coloured, with microlites of uniform size. Feldspars fresh, plagioclase, not much twinned. Augite fairly abundant; fresh, with brilliant polarisation colours; often twinned; one plate shows marked hour-glass structure.

HYPERSTHENE-ANDESITE.

This is a compact dark greenish-grey rock cut 125 ft. north of Queen of Beauty shaft at the Thames, in the north crosscut from No. 11 level, 748 ft. deep. Ground-mass very clear, dusted with magnetite. Feldspars plagioclose; fresh, but clouded with inclusions; not much twinned. Hypersthene often outlined or replaced with black dust; generally affected with decomposition. No augite detected.

This rock forms the Exchange bar, one of the best-known bars or undecomposed cores of andesite which traverse the Thames Goldfield, running parallel with and separating the main lode systems of the field. At the 748 ft. level it was found to be 60 ft. wide; in the Exchange shallow level, due north-west, about 90 ft. thick; and in the 452 ft. level of the May Queen Mine, at a point about 450 ft. north of the Queen of Beauty shaft, 300 ft. thick. Like many of these hard blue bars, it shows a marked tendency to thin out in depth.

HYPERSTHENE-AUGITE-ANDESITE.

A compact dark greenish-grey rock, cut last January a few feet from the foot-wall of the Golden Age lode in the Moanataiari Mine, at the 100 ft. level, Point Russell section. Ground-mass clear, but not abundant. Feldspars plagioclase; fresh, often clouded with microlites and glass inclusions; not much twinned; mostly basic. Hypersthene more abundant than augite; contains enclosures of glass; often altered to serpentinous products, and much dusted with magnetite.

AUGITE-ANDESITE, TAIRUA.

This is a dense fine-grained rock with a vitreous or glassy lustre and conchoidal fracture. It occurs as isolated fragments and large masses weighing many hundredweights on the hills around and south of Tairua Broken Hills Mine,

* Hutton, Proc. Aust. Assoc. Ad. Sc., 1888, p. 7.

being evidently derived from the Tairua andesitic tuffs. The masses generally present a corroded and often ropy appearance, with a pitted surface. Under the microscope it is seen to consist of a very pale-yellow glassy ground-mass, with scattered feldspars and augite, the former occurring as narrow laths and phenocrysts, apparently representing two crops of generation. The feldspar laths are arranged with their principal axes parallel to the fluxion plane. Some binary twins do not exhibit straight extinction, and cannot be sanidine. The majority of the feldspar microliths and plates appear to be plagioclase. Augite is fairly abundant, often well formed and generally twinned. Occurs both as plates and narrow laths, which lie with their long axes parallel with the fluxion plane. Polarisation colours very brilliant. One phenocryst, showing multiple twinning, encloses two crystals of feldspar. Magnetite not very abundant.

Andesitic Glass, Omahu Hill.

This is a black semi-vitreous rock speckled with white feldspars. Lustre vitreous; feels rough. It occurs as irregular masses in the grey tuffs on the Omahu Bridle-track, about a quarter of a mile on the Thames Valley side of Odlam's gold-mining claim. Under the microscope it is seen to consist of a grey glass exhibiting wavy fluxion lines, and surrounding a few large and badly developed phenocrysts of plagioclase. Some patches of the base are partially devitrified and crowded with microliths of feldspar and augite. Augite is fairly abundant. A little magnetite is dusted throughout the base.

Art. XLI.—*On the Secular Movements of the New Zealand Coast-line.*

By Professor James Park, F.G.S., Director, Otago University School of Mines.

[*Read before the Otago Institute, 12th November, 1901.*]

The solid ground is popularly considered the symbol of stability, but exact observations in the older-peopled countries of Europe have shown that, on the contrary, the crust of the earth is in a state of constant oscillation. The upheaval or depression of the land from this secular movement is so slow and gradual as to produce no appreciable difference in the physical aspect of the ground affected from year to year, and it is only after the lapse of generations, and

by means of careful measurements, that it can be proved to exist. It is only along the coast-line, where sea-level affords an unvarying base of verification, that these tranquil movements can be detected and measured.

As early as 1730 Celsius, the Swedish astronomer, had noted the gradual rise of the Scandinavian Peninsula. In 1731, in company with Linnæus, he placed a stone mark at the base of a cliff in the Island of Loeffgrund, not far from Jefle, and thirteen years afterwards was able personally to verify that the Baltic Sea had retreated 7 in., or at the rate of 4 ft. 5 in. for a century.*

That the rate of movement is not always uniform over wide regions, but differential, is shown in the case of the Baltic shores of Scandinavia. For example, at the northern extremity of the Gulf of Bothnia, at the mouth of the Tornea, the continent is emerging from the sea at the rate of 5 ft. 3 in. in a century, but by the side of the Aland Isles the rise, according to Reclus, is only at the rate of 3 ft. 3 in. in the same time. South of the isles the rate of upheaval is even slower, and further south the ground moves so slowly as to appear quite stable even in a century. This region, indeed, seems to be the pivot of the oscillation, for further south, at Scania, the most southerly part of Sweden, the land is sinking gradually, as proved by the submergence of forests and older streets of the towns of Trelleborg, Ystad, and Malmoe. It was at Scania that Linnæus, in 1749, exactly determined the position of a stone, which was found after a lapse of eighty-seven years to be 100 ft. nearer the water's edge. According to Erdmann the subsidence at Scania has now ceased, or has been exchanged for an upward movement, but it will require observations extending over another half-century to verify this conclusion.†

Celsius and his contemporaries were impressed with the view that the emergence of the land was due to the recession of the sea, the changes in the relative level of sea and land being ascribed to variations in the form of the oceanic envelope. Most of the evidence available is adverse to this conclusion, and modern geologists and physicists alike are in favour of regarding the relative changes of land and sea as due to movements of the solid land only. The mean level of the sea is now generally regarded as a constant datum, not necessarily unvarying, but varying within such infinitesimal limits as to be practically constant as a verification datum.

The principal evidences of an elevation of the land are raised beaches, sea-worn caves at present beyond the reach of

* "The Earth," Reclus, p. 621.

† Geol. For. Stockholm Forhandl., i., p. 93.

the sea, elevated sea-ledges and terraces, human records and traditions. A subsidence of the land is more difficult to trace, as each successive sea-margin is washed away or covered over as the submergence continues. The existence of a submerged forest, of fringing coral islands, or of fiords, may be regarded as perfectly reliable evidence of subsidence. In studying the oscillations of the earth it is necessary to guard against the numerous causes of error that may arise from the unceasing struggle being waged between the land and sea. Neither the encroachment of the sea on the shore-line, which may be due to progressive erosion, nor the recession of the sea, which may be due to local accumulations of alluvial detritus, are to be accepted as evidence of subsidence without due consideration. And, since secular elevation or depression of the land is always taking place, it is obvious that an encroachment or recession of the sea, due to denudation or reclamation, may coincide with a geologic upheaval or depression. Therefore in searching for proofs of such movements the student must be on his guard against being deceived by any apparent advance or recession of the sea.

The great and varied assemblage of marine formations in New Zealand, including representatives of nearly all ages, affords ample proof that this country has been subject to many alternating upheavals and subsidences in past geological times.

In the absence of human records it is impossible to definitely or even approximately determine the direction of the present secular movements on our shores. There is abundant evidence that oscillations have taken place in comparatively recent times, but there are no data at our disposal to enable us to ascertain whether the movements which produced this evidence are still progressing in the same direction. An upward motion may be succeeded by a period of subsidence, and in the absence of a means of accurate measurement it would not be safe to generalise on the evidence of what has taken place in some past time, however recent.

The buried and submerged pine forests in the Thames Valley and Bay of Plenty prove that the movement in those regions has been downward up till a very recent date. The extent of this area of subsidence cannot be defined, but the geological evidence clearly indicates that it extended as far west as the shores of Auckland Harbour. Whether this secular subsidence of the Hauraki Gulf is still in progress cannot be determined at present.

A submerged forest on the sea-shore near Waitotara, with the trunks of the trees still standing erect in the sea, points to a very recent subsidence of the land in that region. The

well-known raised beach around Wellington Harbour was upheaved suddenly during an earthquake about forty years ago, and must not be confused with the evidences of slow secular movement.

The raised terraces on the coast-line of Canterbury and Otago, and the recent excavation of the narrow rocky gorges of the Clutha, Taieri, and other rivers draining the east side of the "great divide," point to a slow but continuous elevation of the land which may still be in progress. On the other hand, there can be little doubt that the fiords or sounds of south-west Otago were narrow mountain-glens excavated by subaerial agencies at a time when the land stood at a higher level than at present. The subsidence which has been in progress in that region since post-Tertiary times has allowed the sea to run up and fill the submerged glens. Thus each fiord will mark the site of a submerged valley.

New Zealand, from its insular position, its division by the sea into islands, its numerous harbours and extensive coast-line, is destined to become an important maritime nation. It will always be dependent on the sea for its communications and commerce, both internal and foreign, and this will necessitate the erection and maintenance of harbours, docks, and coast-protection works of a costly and permanent character, specially adapted to accommodate the trading-vessels of the future. It is quite certain that, in the design and erection of these works, the direction of the secular movements of the land will be factors demanding serious consideration. Hence it is now our duty—a duty we owe to posterity—to erect around our shores permanent marks or stones, the positions of which have been accurately determined, for the guidance of the engineers of the future. For example, an accurately determined progressive and uniform upheaval of the floor of a harbour at the rate of, say, 6 ft. in a century would necessitate the introduction of important modifications in the design of dock-accommodation intended to be of a permanent character. Further, it is well known that subsidence in an area allows the accumulation of silts, sand, and gravels in the estuaries, harbours, or rivers in that area; while, conversely, the rising of an area permits the sweeping-away and scouring-out of old accumulations of alluvial detritus in harbours and similar situations. Since the engineer is called upon to combat, or at least direct, the forces of nature, he should be provided with a full knowledge of the direction of these forces, otherwise his best-devised schemes may soon become useless, if not actually destructive.

Stone marks have long since been erected on their shores by most of the civilised maritime states of Europe and America, and the time has arrived when this should be done

here; and not only in New Zealand, but on the shores of the Commonwealth of Australia. It has been shown that the secular movements are so quiet and slow as to produce no appreciable alteration from day to day or year to year. They often require a lapse of several generations to be capable of proof by careful measurement; hence the sooner the marks are erected the earlier will the data be available in the future.

The proofs of upheaval and subsidence are sometimes obtainable over wide continental areas, but generally are marked by a local and variable character; hence, marks should be erected on the shores of all our harbours, on the headlands and outlying projections of land. The work has a high scientific and economic importance, and would naturally fall to the State Department of Lands and Surveys. It could, perhaps, be most conveniently carried on simultaneously with the magnetic survey of the colony now in progress. The marking of the coasts of Australia should be undertaken by the Federal Government, so as to obtain uniformity in the method of determining a mean sea-level datum. Up till now no serious attempt has yet been made to determine the relation of sea-level to the land in New Zealand on a scientific basis, and for this reason the marking of the coast-line with stones, whose position has been accurately determined with respect to sea-level, would further supply a much-needed datum of verification for the officers of the Lands and Survey Department for their more exact geodetic and hydrographical surveys.

Art. XLII.—*Notes on some Glacier Moraines in the Leith Valley, Dunedin.*

By Professor James Park, F.G.S., Director, Otago University School of Mines.

[*Read before the Otago Institute, 12th November, 1901.*]

Plates XXVII.–XXVIII.

The glaciers of New Zealand are reputed to be the largest in existence outside the polar regions, with perhaps the exception of some in the higher Himalayas. They are found clinging to both flanks of the "main divide" of the South Island, their greatest development being within the Province of Canterbury. On the West Coast they descend to within 750 ft. of sea-level, into the midst of the evergreen forest. On the east side, where the slope is more gradual and the

annual precipitation less, the terminal face of the glacier ice is seldom found below 2,500 ft.

An examination of the present physical features of the country affords abundant evidence that the present glaciers are but mere remnants of ice-masses that once covered hundreds of square miles, in many places reaching even to the sea.

In Nelson we have the great tumbled moraines blocking the lower ends of Lakes Rotoroa and Rotoiti; in Canterbury, the marvellous ice-cut terraces on the mountains north of Lake Ohau, and the well-preserved terminal moraines on the plains south of the same lake; and, in Otago, the strikingly beautiful rounded or billowy ice-worn foot-hills of the Matukituki, in the Upper Wanaka, the gigantic moraine blocking the old outlet of Lake Wakatipu at Kingston, and the great ice-shorn plateau of Central Otago, through which the Taieri has cut its narrow tortuous course.

Naturally enough, the most abundant and most obvious evidences of former glaciation are to be found in the vicinity of the present-day glaciers, on the ground the glaciers have passed over twice, once in advancing and once in retreating.

On the other hand, there is nothing to show that New Zealand ever experienced a glacial period corresponding to the Ice Age of the Northern Hemisphere. The evidences of glacier action just mentioned show clearly enough that ice-masses of huge size must have occupied a very large portion of southern Otago and Southland in Pliocene or Pleistocene times; and it seems equally clear that an extension of the present glaciers seaward would explain the origin and source of these ice-masses.

Up to the present time no traces of glaciation have been found in the North Island. The continuous and widespread series of older and newer Pliocene strata in the Wanganui, Wellington, and Hawke's Bay districts, with their rich assemblage of marine forms, proves the existence of long-continued sedimentation in shallow seas, teeming with life, at a period when the great ice-plough was scooping out the valleys of Otago. The circumstance that probably 98 per cent. of this varied fauna is represented by living forms shows that the climate in Pliocene times was neither warmer nor colder than at present.

I do not propose to minutely discuss the causes which led to the refrigeration necessary to permit the great extension of the glaciers of Otago in Pliocene times. This subject has already been exhaustively dealt with by Sir James Hector, Captain Hutton, and others. It will be sufficient to state that the former believed, as the result of his explorations among the West Coast Sounds of Otago in 1863, that an

elevation of 2,000 ft., together with the greater extent of land then existing, but since removed by ice erosion, would be sufficient to extend the glaciers to their former limits.

I will now proceed to describe some morainic mounds which I discovered last June in the Leith Valley, near the foot of Waikari. These moraines are situated near the top of the ridge separating the Leith Valley and Ross's Creek, which flows into the city reservoir. They extend from the saddle between the Leith Valley and Ross's Creek southward, running parallel with the Leith Valley and terminating in Mr. Henry Skey's farm, Section No. 74, at a point nearly due north of the upper reservoir. Although near the top of the ridge, they lie on the fall into the Leith. There are two lines of mounds parallel to each other. The upper mound, about 500 ft. above the sea, begins inside Mr. Skey's boundary, crosses the road, and runs in a west-north-west to east-south-east direction for about 5 chains, gradually increasing in height towards the saddle until it suddenly ends in a pile of andesitic rocks. At a point about half its length it is 8 ft. high, presenting a steep face to the south and a long gentle slope to the Leith Valley. Numerous tree-stumps and clumps of native forest around the saddle indicate that the whole ridge was at one time covered with forest. At the present time a rimu (*Dacrydium cupressinum*), 4 ft. in circumference and 50 ft. high, is growing in the depression of the lower mound. The lower mound resembles a line of massive earthwork constructed for defensive purposes. It is cut through by a road, and is seen to be composed, at that point, of fragments of rotten rock now forming compact yellow clays. The composition of this mound is also seen in a recent cutting, 10 ft. long and 4 ft. deep, near its western end and on its lower slope, which exposes a confused mass of andesitic rocks and clay. The rocks are mostly angular, tabular in form, and often of enormous size. The pile of tumbled rocks at the western end of the upper morainic mound was evidently exposed by the removal of the associated clays by recent denudation.

The high-level terraces in the valley of the Leith and the alluvia west of the saddle would tend to show that the Leith, before the excavation of the present rocky gorge, flowed across Ross's Saddle to the back of Maori Hill, and thence westward in the direction of the present Kaikorai Valley. The present deep narrow valley of the Leith, with its precipitous rocky sides, was obviously excavated in comparatively recent times.

EXPLANATION OF PLATES XXVII.-XXVIII.

PLATE XXVII.

View of southern end of lower moraine looking north-west.

PLATE XXVIII.

View taken in depression between the upper and lower mounds, looking along the depression in a west-north-west direction.

ART. XLIII.—*On the Septarian Boulders of Moeraki, Otago.*

By A. HAMILTON.

[*Read before the Otago Institute, 12th November, 1901.*]

Plates XXIX.-XXXV.

IN the year 1848 Mr. Walter Mantell, as Government Commissioner for the Settlement of Native Land Claims in the South Island, travelled on foot from Kaiapoi to the southern settlements of Otago. An interesting summary of his notes by the way was published by his father, Gideon Algernon Mantell, in the "Proceedings of the Geological Society" for the year 1850 (vol. vi., p. 319).* On page 320 in that publication is a sketch-map of the geology of the coast-line so far as could be gathered from his daily observations and from information obtained from the natives, who at that time were fairly numerous. Names of rivers and coastal features are given from Kaiapoi to the Molyneux River. On reaching what he calls Onekakara Bay he gives a sketch taken a little south of Hampden, looking to the north, including the coastal features as far as the "White Bluff," and in the foreground is "a group of septarian boulders, called by the whalers 'The Ninepins.'"

Mr. Mantell says, "Midway between the bluff and Moeraki the clay contains layers of septaria varying from 1 ft. to 5 ft. and more in diameter. Hundreds of these nodules, which had been washed out of the undermined clay cliffs by the encroachment of the sea, were scattered along the beach. Some were subglobular, others spherical, many were entire, whilst others were broken and glittered with yellow

* "Notice of the Remains of the *Dinornis* and other Birds, and of Forest and Rock Specimens recently collected by Mr. Walter Mantell in the Middle Island of New Zealand, with Additional Notes on the Northern Island, by Gideon Algernon Mantell, Esq., LL.D., F.R.S., G.S., &c. With Note on Fossiliferous Deposits in the Middle Island of New Zealand, by Professor E. Forbes, F.R.S., &c."

and brown crystals of calcareous spar, with which all the hollows of the septaria were lined or filled. Some of these masses were hollowed out by the action of the waves into regular basins, which at lowtide stand up from the sands full of water, and are 3 ft. or 4 ft. deep."

He then notices the zones or belt of cone-in-cone clay with which they were encircled, and gives diagrams and sections. The diagram is interesting as showing a fragment of bone, not in the centre, as a nucleus, but close to the outer edge. The septarium is a small one in this instance, being 2 ft. in diameter, and the piece of bone enclosed ran straight into the mass. The fragment of bone was flattened, 1½ in. in longest diameter; "its cancellated structure appears to resemble that of the moa." A note appended by Dr. Mantell (see below) states that slices prepared for examination under the microscope showed the bone to be avian. It would be of great interest to have the fragment re-examined, as neither Dr. Mantell, Mr. Tomes, nor Mr. Bowerbank do more than state that the microscopical characters show that the bone belonged to a bird. Dr. Mantell was not aware at that time of the occurrence of reptilian bones in nodules and boulders at Katiki, the Amuri Bluff, and in similar beds in other places. The probabilities are, I think, more in favour of its being reptilian than moa, more especially as no moa-bone has since been found in beds of equal age. The fragment is, I believe, still in the British Museum.

Since their discovery the remarkable character of these septaria has attracted successive generations of visitors, and nearly all the smaller specimens have been removed to adorn(?) the corners of paths and the grottoes of the suburban villas of the ingenious. Many years ago an attempt was made by the late Mr. J. T. Thomson to manufacture cement from them, a proceeding probably suggested by the analysis given by Dr. Mantell, and made at the Museum of Practical Geology in London, showing 66·7 per cent. of carbonate of lime. Dr. Mantell also compared them with the septaria extracted from the London clay on the coast of Sussex, which are made into first-class Roman cement. They occur in abundance in the Isle of Sheppey, and are dredged for off Harwich and in Chichester Harbour.

Judging from the sketch given by Mr. Mantell, the septaria were at the time of his visit well exposed. At the present time the sand appears to shift very frequently, and at times nearly covers the boulders. My photographs (see plates) were taken at lowtide, and show that at present about half of each stone is visible. There is one well down between tide-marks which is much broken on the landward

side, and has in its hollow a most charming natural aquarium, the sides and bottom of which are thickly lined with Sabellids, sponges, and beautiful sea-anemones (see Plate XXXII.). Mr. Mantell, with the feelings of a weary, footsore, pedestrian explorer, exclaims, "What an excellent footbath!"—a suggestion practical if not poetical. There is one very large specimen still imbedded in the clay cliffs about 50 ft. above tide-mark, but I could not see any of the smaller sizes. The majority of those between tide-marks are encircled with a thick coating of the small blue-black *Mytilus*, and the bare portion is partly covered with a vivid-green *Alga*, which contrasts with the mussels. Those above tide-limits are weathered to a greyish-brown, and in some cases the hard calcite filling the septæ, or cracks, stands out in relief, being less easily acted upon by the weather. Four or five large specimens have fallen to pieces and show the interior to be a hard blue clay or limestone, and numerous exterior layers, which show more and more the cone-in-cone structure as they approach the surface.

The Maori has localised the tradition of the loss of the celebrated canoe "Arai-te-Uru" in the neighbourhood by pointing out the long reef just south of Port Moeraki as the canoe, and the cargo may still be seen strewn on the beaches, a huge elongated concretion being the *hinaki*, or eel-basket, of Hape-ki-taurake and the slave Puketapu.* The globular septarian boulders are the calabashes which held the supply of water for those in the canoe, and a number of strangely shaped ferruginous concretions which occur to the south of the headland at Katiki are the kumaras washed ashore from the wreck. Mr. Mantell speaks of these "kumaras" as "nodules containing a far larger amount of iron and less lime than those before mentioned. The spot is known to the whalers as 'Vulcan's Foundry.'"

These Katiki Beach boulders are also much in request for garden ornamentation. The natural red-brown colour is often improved(?) by a coat of white paint or white-wash.

Mr. Shortland visited this part of the coast in the early days and notices the story of the canoe and the kumaras, but does not seem to have seen the larger groups of septaria to the north.†

From the geological or stratigraphical point of view the boulders have been frequently referred to in the Reports of the Geological Survey. In 1862 Sir James Hector indicated the position of the Moeraki septaria beds in a paper on the

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* Canon Stack: "Traditional History of the Southern Maoris" (Trans. N.Z. Inst., x., 61).

† Shortland: "Southern Districts of New Zealand," p. 190.

geology of the Manuherikia Valley, and also in 1864, when he determined the succession of the beds in the Shag Point district. Sir Julius von Haast reported on the Shag Point coalfield in the Geological Reports for 1873–74, page 25, and Captain Hutton, describing the Waipara formation in the geology of Otago, refers to the septaria of Moeraki. Another colonial geologist, Mr. Cox, in his report of 1877, refers to their stratigraphical position in connection with the Shag Point series of beds. Still later Mr. McKay examined the geology of the coast-line from Moeraki Peninsula to Kakanui,* and states that "overlying the lower greensands are some dark muds or carbonaceous clays more than 100 ft. thick, which in these lower beds contain the celebrated Moeraki boulders, which, whether spheroidal or flattened, are usually enveloped in a coating of cone-in-cone limestone."

Flattened boulders covered with cone-in-cone limestone are seen in the bed of the Little Kini Creek, opposite Hampden Railway-station. The beds containing boulders reach the beach at the mouth of the creek; but there they are mostly flattened, and it is only when seen further south within tide-marks that they take the perfectly spheroidal form. There are also spherical and elliptical ferruginous concretions on the Katiki Beach, on which a few saurian remains have been found.

In the report for 1890–91, page 47, Mr. McKay has a humorous and lucid description of the difference between the grey and the brown "boulders."

Sir James Hector also refers to them in his appendix to the same report (page 173). Captain Hutton, in his "Sketch of the Geology of New Zealand,"† includes the beds in his Pareora system.

Analysis of Moeraki Boulder.

Carbonate of lime	66·7
Silica	16·2
Alumina	10·4
Peroxide of iron	4·7
Organic matter	2·0
	100·00

Contained when received 2 per cent. of water.

Note on the Fragment of Bone referred to above.

The external form of this fragment conveys no idea of its nature; but slices carefully prepared for the microscope

* Rep. of Geol. Survey, 1886–87, p. 223.
† Quart. Journ. Geol. Soc., May, 1885.

present, under a moderately magnifying power, a structure which shows that the bone belonged to a bird. There is, however, no proof that it can be referred to the *Dinornis*. Mr. Tomes and Mr. Bowerbank, who have obliged me by examining the specimen, concur in this opinion. Insignificant as this fact may appear, still, in these early pages of the palæontological history of our antipodean colonies, it is worthy of remark that the first-discovered fossil relic of the terrestrial Vertebrata in the Tertiary strata of New Zealand should belong to that class which, in later periods, constituted the principal types of the warm-blooded animals of the fauna of that country, to the almost entire exclusion of the Mammalia. —G. A. M.

DESCRIPTION OF PLATES XXIX.-XXXV.

Plate XXIX.	Moeraki Beach, with septaria.	
Plate XXX.	" "	
Plate XXXI.	" "	
Plate XXXII.	" "	weathered.
Plate XXXIII.	" "	decomposed.
Plate XXXIV.	Cone-in-cone limestone.	
Plate XXXV.	" "	

ART. XLIV.—*Note on an Artesian Well at Aramoho.*

By J. T. STEWART, C.E.

[*Read before the Wellington Philosophical Society, 6th August, 1901.*]

ABOUT three miles above Wanganui, on the Wanganui River bank, a 4 in. bore has been made by Mr. John Walker, jun., in search of water. There is, of course, much speculation as to where the water comes from. It is struck under a layer of papa (280 ft. thick), and water was struck at bottom of this layer, at 540 ft. below the surface, in a layer of sand intermixed with pumice sand. The surface here may be 30 ft. to 40 ft. above the sea. Perhaps the water gets under the main papa stratum where it has been pierced by the volcanic heights about Ruapehu and Tongariro and follows down under the papa formation to where found. I found the temperature of the water coming out of the pipe at the surface to be 70½° Fahr., while the adjoining river-water was 42° at 6 ft. under the surface. The temperature in the shade at the time was 45°.

A few years ago a 2 in. bore was put down at the same

place and water was got at the same depth, and this has continued to supply houses in the neighbourhood successfully.

The new bore is 11 ft. off the old bore, and does not seem to affect it. This bore is about 1 chain off the river-bank on the right bank of the river.

Before this a trial bore, 14 chains down the river and 4 chains off the bank, was put down by Mr. Walker to 610 ft., but no successful water-supply was got, and no solid papa stratum was reported there.

The following notes were given to me by Mr. Walker :—

From surface to 60 ft., sand and pumice.
60 ft. to 66 ft., sand.
66 ft. to 105 ft., clay.
105 ft. to 117 ft., sand (wood at 110 ft.).
117 ft. to 127 ft., shingle.
127 ft. to 130 ft., sand.
130 ft. to 138 ft., shingle.
138 ft. to 144 ft., coarse grit.
144 ft. to 183 ft., sand.
183 ft. to 183½ ft., hard seam (taking five hours to bore).
183½ ft. to 185 ft., fine sand.
185 ft. to 239 ft., papa.
239 ft. to 260 ft., sand.
260 ft. to 540 ft., papa.

At 540 ft. water came up strongly, after boring through a hard seam. The water was got in sand intermixed with fine pumice, into which the rods were put down to 553 ft. The bore is piped with 313¼ ft. of 4 in. pipe, the top of last length being 15 in. below the surface (the rest of the bore has no pipe). A strong volume of water was got, with a good pressure.

Art. XLV.—*The Volcanic Beds of the Waitemata Series.*

By C. E. Fox.

[*Read before the Auckland Institute, 24th February, 1902.*]

Plates XXXVIII.-XL.

1. Introduction.

The Waitemata series is a group of strata developed round the shores of the Waitemata Harbour, from which it derives its name. The upper limit of the series is well defined, since a complete unconformability exists between its shales and

sandstones and the overlying tuffs and lava-streams, which are of Pliocene or later age. The lower limit is not so certain. In this paper it is taken to be the Papakura limestone, which crops out along the Palæozoic ranges to the east of the Waitemata Harbour, lying unconformably on the upturned and denuded edges of ancient slates and phyllites. This limestone is considered by Captain Hutton to be Oligocene in age, while the beds in the vicinity of Auckland are classed as Lower Miocene. If this classification be accepted the volcanic beds with which this paper deals are Lower Miocene, some of them Oligocene perhaps.

Above the limestone lies a thick group of greensands. These are succeeded by sandstones and shales, evidently deposited in somewhat shallow water, for ripple-marks and current bedding may frequently be observed in them. There is some doubt as to whether an unconformability exists between the greensands and the overlying beds, Captain Hutton and Mr. S. H. Cox, F.G.S., both holding that there is one,* while Mr. James Park, F.G.S., believes the evidence to point to a regular succession.† At least the unconformability cannot be very great if we judge by fossil evidence.

About the time when the limestone was being formed to the east of the Waitemata there rose through the Oligocene sea to the westward a long line of volcanic vents, now denuded and overgrown with dense forest, and known as the Waitakerei Range. There is no means of ascertaining its exact extent or the nature and position of the vents. These Waitakerei outbursts gave rise to a thick bed of coarse volcanic fragments. As the bed occurs typically at Cheltenham, it may be called the Cheltenham breccia. This is the oldest of the volcanic beds of the series.

Twenty or thirty miles to the eastward another line of vents became active at nearly the same time, on Coromandel Peninsula. The Coromandel eruptions, however, would seem to have commenced rather earlier than those at the Waitakerei, and to have continued for some time after the western vents had become quiescent. The *débris* from the Coromandel volcanoes was spread over the floor of the sea, and possibly it was these eruptions which supplied the material for the Parnell grit, the youngest volcanic bed of the series.

Between these two main beds, the Cheltenham breccia and the Parnell grit, there are other but less important beds of volcanic origin which seem to have been all derived from the Waitakerei outbursts. Each of these seems to be less coarse

* Trans. N.Z. Inst., 1884.
† Trans. N.Z. Inst., 1889.

than the preceding one; and they mark, I believe, the gradual dying-out of volcanic activity along the Waitakerei Range.

The general evidence for the age of the beds is of a threefold character. In the first place, there are the fossils contained in the beds themselves—the palæontological evidence. This alone would show that the Cheltenham breccia cannot be Pliocene, as the Geological Survey contends. In the second place, there is the composition of the contained lava. In New Zealand, as in other places, there seems to be frequently a regular succession. The earlier eruptions are sometimes basic. These, however, are succeeded by acid lavas, and these again by more basic, the lava of a "petrographical province" growing more and more basic till the cycle is completed. The lavas of Pliocene age in Auckland are olivine basalts. The lavas of the volcanic beds of the Waitemata series are pyroxene-andesites; and, since the Eocene lavas are generally rhyolites, the evidence seems at least favourable to a Miocene or Oligocene age for the Waitemata lavas. The exceptions to this rule make it impossible, however, to rely on the lithological evidence alone—or, indeed, to lay much stress upon it. The last line of evidence is the position of the beds—the stratigraphical evidence. At Orakei Bay there is a very fossiliferous greensand of whose Miocene age there can be little doubt. It will be shown that the volcanic beds are all below the greensand, with the exception of the Parnell grit, which is above it.

Generally the beds of the Waitemata series are either horizontal or dipping in long gentle anticlines and synclines; but in places they are distorted and dislocated, and may even be thrust over each other. It has been generally supposed that these strains and the numerous faults are due to the volcanic forces which produced the basalt puys, scattered in scores round the Waitemata. Sometimes, perhaps generally, the distortions occur in proximity to a puy. At other times no such apparent connection is visible, and the strata may be disturbed far from any basalt cone, or may lie horizontally quite close to one. It may be that the small puys are no true measure of the magnitude of the volcanic forces that formed them, and that, as in Scotland, when denudation lays bare the underlying rocks great sills will be found whose contents never reached the surface.*

In working out the stratigraphy of the Waitemata series the volcanic beds are invaluable. They are widespread, and their lithological characteristics are much more distinct than those of the sandstones and shales. Moreover, some of the

* Sir A. Geikie: "Ancient Volcanoes of Great Britain," vol. i., p. 458.

tuffs are comparatively rich in fossils, whereas the sandstones and shales are generally lacking in organic remains.

2. Previous Observers.

Hochstetter was the first to describe the Waitemata series, in a lecture delivered to the Auckland Institute in 1859: "The horizontal beds of sandstone and marl which form the cliffs of the Waitemata and extend in a northerly direction to Kawau belong to a newer Tertiary formation, and, instead of coal, contain only layers of lignite. A characteristic feature of this Auckland Tertiary formation is the existence of beds of volcanic ashes, which are here and there interstratified with the ordinary Tertiary layers."*

Captain Hutton showed in 1870 that the beds could be followed in an easterly direction to the Hunua and Wairoa Ranges, composed of Palæozoic slates. He thought that the estuarine sandstones forming the upper part of the series were separated by an unconformability from the greensands and limestone to the east.†

Mr. S. H. Cox, of the Geological Survey, traced the beds to the north some ten years later. At Komiti Peninsula he found Lower Miocene fossils associated with the forms found in the Orakei Bay greensand. He therefore concluded that the Waitemata series was Lower Miocene.‡

Sir James Hector, Director of the Geological Survey, thought that the series should be divided at the Parnell grit; the beds below this he classed as Cretaceo-tertiary, those above it as Lower Miocene. This seems to have been the first occasion when the importance of the Parnell grit as a stratigraphical guide was realised.‡

Mr. McKay, of the Geological Survey, examined the district in 1883. He agreed with Sir James Hector in the division of the series; considered the "Fort Britomart" shales the equivalent of the Orakei Bay greensand, and showed the Parnell grit lying unconformably on the former; and identified the Cheltenham breccia with the Parnell grit on stratigraphical grounds.§

Captain Hutton, in 1884, showed that there was no evidence of an unconformability between the Orakei Bay greensand and the Parnell grit; that there was no evidence that the latter was younger than the former; and that the Orakei Bay bed was of Miocene age.||

Mr. James Park, of the Geological Survey, made an

* "Reise der 'Novara': Geology," i., p. 34.
† Trans. N.Z. Inst., vol. xvii, p. 307.
‡ Geological Reports, 1879–80.
§ Geological Reports, 1883–84.
|| Trans. N.Z. Inst.

examination of the district in 1885. He collected a great deal of new evidence as to the stratigraphical position of the Parnell grit, which he was inclined to think inferior to the Orakei greensand; identified the Parnell grit with the Cheltenham breccia on palæontological grounds; traced the whole series eastward to the Papakura limestone; and concluded that the Waitemata series was unconformable to the Cretaceo-tertiary beds. His final classification was as follows:—

Upper Miocene.

1. "Fort Britomart" shales.
2. Parnell grit and Waitakerei breccias.

Lower Miocene.

3. Turanga greensands.
   Orakei Bay greensand.
4. Papakura limestone.
   Cape Rodney grits.*

Sir James Hector still thought the series should be divided at the Parnell grit. He dissented from Mr. Park's view that the Cheltenham breccia was the northerly extension of the Parnell grit, considering the Cheltenham breccia and the other volcanic beds to the north of the harbour of Pliocene age, and quite unconformable to the Waitemata series.†

Mr. Park, in 1889, upheld his views as given above.‡

Since 1889 nothing of importance has been published on the volcanic beds of the Waitemata series. The view adopted in the present paper has been already indicated in the introduction.

3. The Volcanic Beds of the Series.

As the volcanic beds at Cheltenham and Parnell are the thickest, most fossiliferous, characteristic, and widely spread beds of the series, and their stratigraphical position and age have been a subject of much dispute, most of the paper will be devoted to a consideration of them. The evidence tends to show that they are distinct beds, though Mr. McKay and Mr. Park consider them identical, and Mr. Park writes that he has "conclusively proved" their identity. Sir James Hector considers the Cheltenham breccia to be Pliocene, so that it will be necessary to give in some detail reasons for supposing it to be Lower Miocene, or even Oligocene. With regard to its source, I will give evidence tending to show that it probably came from the Waitakerei vents. The chief point

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* Geological Reports, 1885.
† Geological Reports, 1885–86.
‡ Trans. N.Z. Inst., 1889.

of interest with regard to the Parnell grit is whether it is above or below the Orakei Bay greensand, because the latter is a fossiliferous bed which is allowed to be Miocene. Mr. Park felt inclined to place it below, although admitting the evidence inconclusive, and he has since classed it as Eocene.* But a large amount of new stratigraphical evidence will be given which leads me to think that it is really above the Orakei greensand, and therefore Miocene. Its source is an open question; it may have come from the Waitakerei, but there is evidence in favour of its having come from the Coromandel vents. There are at least two other volcanic beds. One of these really consists of a group of tuffs separated by thin layers of shale. They are well developed at Wairau Creek, and so I have called them the "Wairau tuffs." The other bed is a feldspathic tuff, developed best at Ponsonby, and called throughout the "Ponsonby tuff." These can be dealt with more shortly.

I consider that the thick volcanic breccias on the west of the Waitakerei Range should really be included in the Waitemata series, but I have not been able to examine them sufficiently to include a discussion of them in this paper.

4. Are the Cheltenham Breccia and the Parnell Grit distinct Beds?

The study of the volcanic outcrops at these places has led me to the conclusion that these beds are distinct. The evidence is considerable, consisting of a number of facts which are cumulative. Before giving them it will be advisable to give the evidence in favour of the identity of the beds.

Mr. Park, in 1885, came to the conclusion that the outcrop at Cheltenham, on the north side of the harbour, was simply a northerly extension of the outcrop at Parnell, on the south side. Sir James Hector dissented from this, and wrote: "The Parnell grit, which has been much relied on in discussions concerning the Waitemata formation, has in many cases been confounded with the volcanic grits and conglomerates in other parts of the district"†—*i.e.*, with the Cheltenham breccia. Mr. McKay, too, who had been the first to suppose the beds identical, wrote: "As a consequence of my admission that the Parnell grit does or should pass under the Fort Britomart and Calliope Dock beds, and of the observed fact that the breccias north of Cheltenham Beach overlie them, I am forced to agree with Sir James Hector that the Parnell grit and Cheltenham breccia do not

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* "Thames Goldfields": Park and Rutley, 1897.
† Geological Reports, 1885–86.

occupy the same horizon, and that the Parnell grit is the older."*

This led Mr. Park to defend his views.† To Mr. McKay he replied that the Cheltenham breccia might quite possibly underlie the Calliope Dock beds, because a basalt cone of more recent date lay between the two and obscured their stratigraphical relations. This was, so to speak, negative evidence; but he added that at Parnell, in the lower 2 ft. of the grit, he was fortunate enough to find some fossils (a *Pecten*, a *Cerithium*, a *Teredo*. and several small corals), and he wrote: "The *Cerithium*, *Pecten*, and corals are the same as those found in the breccia at Cheltenham, thus proving conclusively that the Parnell grit is the southern extension of that stratum, deposited at the same time and under the same geological conditions." Mr. Park made good use of his fossils. As he does not give even the generic names of the corals they need not be considered. Surely it is possible for two beds of nearly the same age to have *Pecten polymorphoides* and an unknown *Cerithium* associated together, especially as *Pecten polymorphoides* has a wide vertical range and is a common Miocene fossil.

As far as I know this is all the evidence in favour of the beds being identical. Since, however, the beds are both volcanic breccias and similar, and there is a stretch of water two miles in width between the two, it is reasonable to suppose them identical unless there is good reason for thinking them distinct. The evidence for the latter view is as follows:—

(1.) The beds are not entirely similar in lithological characters. In the case of the Cheltenham breccia the bed consists almost entirely of volcanic fragments, some of them (though this is rare) 8 in. in diameter. In the Parnell grit most of the fragments are greensand, slate, &c., while only in the lower layers do we find volcanic fragments of any size, and these are rounded, well-worn scoria, generally oxidized, and never more than 1 in. in diameter. There are other minor differences, but the difference in texture is the point which I wish to emphasize: in the one bed numerous lumps the size of an orange, hard, black, and angular; in the other, red, rounded, scoria fragments not larger than marbles. This difference is brought prominently before one when trying to obtain a suitable fragment at Parnell from which to make a microscopic section. It must be remembered that the Parnell outcrop is not more than two miles and a half from the Cheltenham outcrop. It is in that distance that the texture

* Geological Reports, 1888–89.
† Trans. N.Z. Inst., 1889.

alters so remarkably. This line of argument is immensely strengthened by some outcrops hitherto unrecorded. The most interesting of these are some reefs in the harbour which are uncovered at lowtide and may then be examined. I cannot do better than represent these various outcrops diagramatically. The positions are shown by an X and Y respectively, the Y standing for the bed with coarse texture and the X for the bed with fine :—

Birkenhead. X — Cheltenham. Y

← to the Waitakerei.

X Shelly Beach. — X 1st reef.

X Judge's Bay. — Y 2nd reef.

↑

X St. John's College.

Now, it can be shown that very probably the coarse bed is derived from the Waitakerei vents, and it is difficult to see how such a distribution as that shown above could be effected. How is it that none of the large blocks reached the spots marked with an X, while great numbers reached those marked with a Y? Supposing this due to currents, those currents must have been somewhat peculiar ones. But this argument from variation of texture does not stand alone ; it is supported by much stronger ones.

(2.) The fossil contents of the beds are different. I have examined more than half a dozen outcrops of the coarse bed at widely separated localities, and more than a dozen outcrops of the finer bed at spots equally far apart. In every one of the former fossils are plentiful, especially *Bryozoa* and *Pectens*, the total number of fossils in the coarse outcrops amounting to more than forty species. In more than twice as many outcrops of the latter I found scarcely any fossils, a species of *Bryozoa* (*Fasciculipora ramosa*) being the only usual one. Moreover, the fossils of the coarse bed* show a blending of Miocene and Oligocene forms just as we find in the Papakura limestone, while the fine bed can be shown on independent evidence to be decidedly Miocene.

(3.) The stratigraphy gives direct evidence in favour of the beds being distinct. I cannot mention all the minor facts which receive an explanation on this hypothesis and become difficulties on any other. I shall merely mention the two clearest indications that the beds are distinct.

* List on page 468.

(*a*.) At Lake Takapuna (Wairau Creek), about 30 ft. above the outcrop there of the coarse bed, are the black-banded Wairau tuffs. At St. John's College black-banded tuffs, apparently the same, occur some 70 ft. below the fine bed. Neither section is completely exposed, but I could see no sign of a break.

(*b*.) At the Manukau Harbour, where the occurrence of these beds does not seem to have been hitherto observed, two outcrops occur, a quarter of a mile apart. One is a coarse bed with fossils, ten species of the *Bryozoa* being also found at Cheltenham, as well as *Pecten burnetti* and *Rhynchonella nigricans*. The other is a fine-grained bed, in every way resembling the bed at Parnell, except that its fragments are slightly smaller and its thickness rather less. The coarse-grained bed has larger fragments than at Cheltenham, which is natural enough if the Waitakerei vents were the source; so that the difference in texture between the two beds is accentuated (Plate XXXVIII., fig. 1).

The section cannot be seen in a direct line since two small bays occur at *x* and *y*; but there is no break possible except at one point, the head of the inlet at *y*, where there has been a fall of *débris*, so that no section can be seen. This slip may mark a line of fault, but as the beds have the same dip on both sides of it and are similar, and there is no sign of distortion of the strata, there seems no reason to suppose one. The coarse bed is here about 30 ft. thick, the other perhaps 12 ft.

I wrote that the evidence was cumulative—*i.e.*, the stratigraphy and the palæontology both point to two beds. In fact, it seems to me improbable that so many fossils should be preserved invariably in the coarse bed and never in the fine; that the texture should vary so rapidly; and that the stratigraphical relations given above, sometimes fairly clear, sometimes obscure, but always indicated, should be always misleading.

Accepting, then, the conclusion that the beds are two distinct formations of different date, it will be well to consider them separately; and, first, the Cheltenham breccia, because it is the older.

5. The Cheltenham Breccia.

The Cheltenham breccia presents usually a bedded appearance, due to the arrangement of fragments of approximately the same size in roughly parallel bands. The coarsest band is usually about a third of the way from the bottom, and the angular fragments scattered through this band are as large as apples. These fragments are imbedded in a matrix of smaller *débris*, which forms the rest

of the bed. Next to this main band the lowest layers are the coarsest, those above shading off very gradually into a tufaceous sandstone. From these facts it seems probable that the main outburst took place some little while after the vents had become active, and was succeeded by outbursts less and less powerful. The thickness of the bed varies, of course, with its distance from the source: the thickness seems to average about 25 ft. at ten or twelve miles from the Waitakerei Range. When we consider the thickness (3 ft.) of the ash which the violent outburst of Tarawera produced in 1886,* we cannot but be impressed with the magnitude of the eruptions necessary to lay down this coarse and thick breccia. The fossils contained in the bed are generally found either at the top or bottom.

The bed weathers to a black or brown colour when exposed to the air, but in the finer parts is bluish-grey on a fresh fracture. The surface is very irregular, owing to the fact that the lava fragments weather out of the matrix. Near vegetation—along the top of a cliff, for instance—all the colour is generally leached out, the result being a creamy loam; or, if there has been much oxidation, a bright-red stratum forms a band along the summit of the cliff. Zeolite veins running through and through the bed are not uncommon. These veins are not more than $\frac{1}{10}$ in. in width, but extend for yards, and when the rock is weathered they sometimes stand out on the face of the cliff like a network of miniature dykes.

The material of which the bed is composed consists almost entirely of rounded fragments of lava set in a matrix of finer volcanic *débris*. Sometimes the fragments are rough and angular. Occasionally blocks of sandstone or shale are included, and these are sometimes several feet in diameter. Some small fragments of porcellanite also occur.

Besides these constituents there are very numerous crystals of feldspar and augite, sometimes broken, but often retaining very perfect crystalline shape. These, no doubt, were separated from the lava in which they were contained at the time of the explosions. The feldspars are bright glassy forms in little oblong crystals, showing good cleavage. The augite crystals are of two sizes. The smaller and less perfectly formed resemble those in the lava; but occasionally much larger forms may be found up to 1 in. in length, distinguished from the former both by their larger size and more perfect crystalline form. Large crystals, and especially large augite crystals, appear to be frequently observed in tuffs deposited at no great distance from a vent. Their origin is obscure, and

* "Eruption of Tarawera," Professor A. P. W. Thomas.

Sir A. Geikie remarks*: "The conditions under which such well-shaped idiomorphic crystals were formed were probably different from those that governed the cooling and consolidation of ordinary lavas." These crystals, however, were found at a greater distance from the vents than is usual, since they must be at least ten miles in a direct line from the Waitakerei Range.

The typical lava of the Cheltenham breccia is an andesite, usually an augite-andesite, but hypersthene-andesite is also present, as is the case at the Coromandel, a parallel line of activity of much the same age. There is occasionally a tendency to ophitic structure, but it is never pronounced, and the ground-mass is typically hyalopilitic. The specific gravity varies from 2·5 to 2·8, but in the majority of cases does not exceed 2·7. This is the more remarkable since a few of the rocks are basalts (but without olivine). This somewhat low specific gravity may be accounted for, however, by several considerations. In the first place, there is frequently a fair amount of dark-brown glass in the ground-mass. Teall gives the specific gravity of andesites as ranging from 2·54 in a glassy to 2·79 in a crystalline state.† In the second place, some of the specimens are highly amygdaloidal, the amygdules forming a large percentage of the rock. They generally consist of chabasite, which has a specific gravity ranging from 2·06 to 2·17, so that the specific gravity of the whole rock fragment would be much lowered. On the whole, then, they may be taken as typical andesites, while a small percentage are basalts without olivine. Except in one doubtful case I have seen no olivine; but a highly basic serpentine, containing 0·47 per cent. of nickel, has been described as occurring at Manukau North Head, so that olivine-basalts may yet be found in the lavas if not in the ejected fragments.

Besides the more basic fragments there are others presenting the appearance of true trachytes, pale-grey in colour, with a specific gravity of 2·54. Occasionally fragments of acid pumice are also present. It is possible that this did not come from the Waitakerei vents. At the Tamaki Gulf, a few miles from Auckland, there are pumice beds, which I consider to be of Pliocene age. They lie unconformably on the Waitemata series, and are due, I believe, to the fact that the Waikato River then flowed into the Auckland sea.‡ Before this, however, it flowed into the sea near Tauranga, in the Bay of Plenty, and it cannot be supposed that it was flowing into the Auckland sea so long ago as Miocene times. Except

* "Ancient Volcanoes of Great Britain," vol. i., p. 62.
† "British Petrography."
‡ Trans. N.Z. Inst.

the Waikato, I see no source from which pumice is likely to have been derived by transport, and it does not occur in the beds below or above the breccia. If the pumice is really part of the ejected matter, we have a large range of lava from basalts to rhyolites, indicating probably a long period of volcanic activity. In the present state of our knowledge, or lack of knowledge, of the Waitakerei lavas it is scarcely safe to generalise, but it is interesting to note that no rhyolites have yet been found *in situ* at the range, though andesites are abundant and andesitic basalts still more common. It is possible that the acid lavas rose in the vents but never flowed out as lava. Dykes and necks are frequently more acid than the lava-flows, and this seems here to be the case.*

I have drawn some sections of the lava as seen under the microscope, but the drawings are merely diagrammatic (Plates XXXIX. and XL.). The shaded portion represents the ground-mass (which is usually opaque, but sometimes consists of a brown glass). Owing to this fact the phenocrysts appear in the diagrams to stand out from the ground-mass more than they do in the rock. The shading, moreover, is not quite true to nature, especially in fig. 1, where the difference in shade between the two generations of augite is accentuated. The mosaic of granules in fig. 2 is only seen, of course, under polarised light.

Fig. 1: St. Helier's Bay.—The ground-mass consists largely of brown glass partly devitrified, and containing numerous laths of feldspar and magnetite. The phenocrysts are chiefly augite, in two generations. The smaller crystals present irregular rounded outlines, and are yellowish-brown in colour; the larger crystals present more regular six-sided outlines, are dark-green, and contain inclusions, especially of magnetite. The phenocrysts of feldspar frequently consist of an outer shell, enclosing brown glass. Others show perfect zonal structure. Striping is absent. There are a few amygdules.

Fig. 2: Deep Creek.—This is a highly amygdaloidal rock, the secondary mineral, which in this case is chalcedony, not only filling the vesicles but also replacing the phenocrysts, none of which appear under the microscope. With polarised light the pale amygdules break up into a mosaic of granules, greys and yellows of the first order being the colours. Each amygdule is bordered by a row of minute granules very regularly arranged, the centre consisting of granules of a larger size. Sometimes streams of small granules connect separate amygdules. Feldspar laths are not numerous in the opaque

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* Sir A. Geikie: "Ancient Volcanoes of Great Britain," vol. i., pp. 61, 62.

ground-mass. A large fibrous mass of yellowish-brown pleochroic bastite appears in the centre of the section. It gives straight extinction along the planes of schillerisation. Under a high power it is seen to be a very pale-yellow mass, with deep-brown prisms arranged in parallel lines, and giving the fibrous appearance. Sometimes little prisms are arranged crosswise, giving a scalariform appearance.

Fig. 3: Cheltenham.—This is a hypersthene-andesite. The ground-mass is hyalopilitic, but the feldspar laths are not very numerous. Grains of magnetite are thickly distributed. The phenocrysts consist chiefly of large striped feldspars, whose extinction angle shows them to be labradorite. Augite also occurs, associated with a rhombic pyroxene, which is probably hypersthene. The colour is paler, however, than in the drawing.

Fig. 4: Onehunga.—This is a very amygdaloidal rock. In the hand specimen it is black, spotted with white amygdules of chabasite, which show under the microscope beautiful fibrous forms. The ground-mass is augitic, with feldspar laths and a little magnetite. The phenocrysts are numerous, especially large striped crystals of labradorite or andesine. Augite is the usual pyroxene, forming very large green six-sided prisms; but pleochroic brownish crystals of hypersthene are also present.

Fig. 5: Wairau Creek.—The ground-mass is typically hyalopilitic, with numerous elongated laths of feldspar, showing flow-structure. Augite is also present in the ground-mass in abundant pale-yellowish grains. Magnetite grains are numerous. The rest of the ground-mass consists of a deep-brown glass, perfectly isotropic.

The phenocrysts consist of plagioclase, but, though binary twinning is common, multiple twinning is very rare, and some of the feldspars are untwinned. Zonal structure is very general. Augite phenocrysts are not very numerous, occurring as pale-green six-sided prisms. The augite and the feldspar contain numerous inclusions of glass and magnetite grains. Magnetite also occurs as large three-sided crystals.

The rock closely resembles an "andesitic basalt," from the Waitakerei Range, which is in the collection of the University College laboratory, the only difference being that multiple twinning is more common in that rock. It also somewhat resembles an "andesitic basalt" from Eskdalemuir, described by Sir A. Geikie.*

Sir James Hector has always distinguished between the Parnell grit and the Cheltenham breccia, but he placed the latter above the former on the strength of a supposed uncon-

* Proc. Roy. Phy. Soc. Edin., vol. v., 1880.

formability. He wrote: "Great potholes, similar to that now occupied by the North Shore Lake [Lake Takapuna], were formed, and these were filled by Pliocene beds composed chiefly of volcanic agglomerates"*—*i.e.*, by the different outcrops of the Cheltenham breccia, each outcrop marking, I suppose, the site of a former lake. Sir James Hector also gave a section at the Wairau Creek to show that the breccia lay unconformably on the Waitemata sandstones. I have repeatedly examined this spot and can find no section closely resembling the one given, so that I think some other locality was probably intended. The breccia does, indeed, occur at the Wairau Creek, but it appears unconformable to the sandstones from which the fine specimen of *Pentacrinus* now in the Auckland Museum was obtained. This appearance of unconformability is, I believe, deceptive, partly due to the effects of current-bedding at the base of the breccia, partly to a series of small faults which obscure the section, and partly to distortion of beds of unequal hardness, which is the reason given by Mr. Park. Mr. Lamplugh has shown how a "crush breccia" may be formed where the strata shade off into one another. Here, however, we have beds of quite distinct hardness, and in that case an appearance of unconformability is generally the result of crushing.

In reply to Sir James Hector Mr. Park wrote: "It should, however, be pointed out that wherever the strata occupy a horizontal or undulating position the breccia is seen to be interbedded with and quite conformable to the adjacent beds, and at its base is frequently more or less false bedded with the underlying clays and sandstones. On the other hand, at points of severe local disturbance where the breccia is present the softer and more yielding clays and soft sandstones have in many instances been crushed and contorted and often turned over the more compact, heavy, and unyielding ash-bed, thus giving rise to apparent unconformity."

Mr. Park's section shows how an inverted-trough fault may produce an appearance of unconformability in beds of markedly unequal hardness. On the weathered face of the cliff the faults and fault breccia are by no means as prominent as they are in his drawing. C is the bed from which *Pentacrinus* was obtained. In a spot where the underlying sandstones were exposed an inverted-trough fault might still more easily cause a deceptive outline.

It is also quite true, as Mr. Park observes, that the unconformable appearance generally coincides with an area of distortion; but this is not universally the case, as at the Manukau Harbour.

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* Geological Reports, 1885, p. xxxviii., woodcut.

I believe that the real reason for this deceptive appearance is to be found in current-bedding. The ancient sea which washed the flanks of the Waitakerei hills was probably studded with islands, of which few now remain. The proximity to the surface, however, of the Palæozoic quartzites and silky slates, some of which the Cheltenham breccia did not cover, is evidence of their former existence. This may have produced violent and conflicting currents which deposited the breccia on the earlier sands and mud-flats in a somewhat irregular way. The Waitakerei hills were not very far distant, and the isthmus of Auckland was then a narrow strait.

The argument for a Pliocene age rests entirely on the supposed unconformability. The argument for a Miocene age rests on overwhelming fossil evidence and also on stratigraphy. The unconformability might not, in any case, be serious, and the appearance may be otherwise explained; but Oligocene fossils, unless derivative, could not be found in a Pliocene bed.

The stratigraphy points to an Oligocene age for the Cheltenham breccia. It may be shown that the breccia is stratigraphically below the Parnell grit; that there is no volcanic bed between the Parnell grit and the Orakei greensand; and that the Cheltenham breccia is consequently inferior to the Orakei greensand—a Lower Miocene bed. It may further be shown that the Orakei greensand is the equivalent in position and fossil contents of the upper parts of the Turanga greensands which overlie the Papakura limestone; and it follows that the Cheltenham breccia is either the equivalent of the lower greensands at Turanga (and therefore at the bottom of the Lower Miocene) or of the limestone at Papakura (and therefore at the top of the Oligocene). The evidence for each of these propositions is given below.

(*a.*) The breccia is below the Parnell grit. This has been incidentally shown in discussing the question of their identity; but it will now be necessary to give the evidence which leads me to consider the coarse beds at Wairau Creek, Cheltenham Beach, and the White Bluff to be all outcrops of one bed. In lithological contents the beds are very similar, differing almost wholly in the varying size of the lava fragments of which they are mainly composed. The arrangement, too, is similar, the coarsest fragments being about a third of the way from the bottom. The agreement in fossil contents is shown in three parallel columns on pages 468–9.

At the White Bluff I had not more than ten minutes to collect, but was fortunate enough to come upon a very fossiliferous patch of *Bryozoa.* With a more careful search I think it very probable that other *Pectens* at least would be found; but, at all events, the fossil contents are very similar. The identifications were made chiefly by a comparison with the

plates and descriptions in Zittel and Stolickza's "Orakei Bay Fossils,"* Waters's papers on "Australian Bryozoa,"† and Tenison-Woods's "New Zealand Corals and Bryozoa."‡ No attempt was made to identify numerous indistinct remains.

(*b.*) There is no volcanic bed between the Parnell grit and the Orakei greensand. The evidence for this will be given when the Parnell grit is described.§ It may also be noted that if the Cheltenham breccia were between the two it must have been erupted at Orakei since the greensand was, or else it must appear in section between the two, but nearer the Parnell grit, at the Orakei Stream.|| It does neither. The breccia therefore underlies the Orakei greensand.

(*c.*) The Orakei greensand is the stratigraphical equivalent of the upper greensands of Turanga. The evidence for this is given better later, and it will be sufficient here to say that the Parnell grit slightly overlies both. Mr. Park found numerous fossils in both, which he compares.¶

I have slightly rearranged Mr. Park's list. A difficulty, however, confronts us in supposing the Cheltenham breccia and Papakura limestone equivalent beds. How is it that the Parnell grit, a thinner bed, extends to the Turanga greensands and the limestone, while the Cheltenham breccia, a thicker bed, does not? If it were certain that the former came from Coromandel and the latter from Waitakerei a sufficient reason is given in that their origins lay in opposite directions. But this is not certain, and I am inclined to offer a different explanation. It will be noticed that round the Waitemata, in early Oligocene times, sandstones and volcanic beds were laid down, while round Papakura limestones and greensands were deposited; so that the two areas have different types of sedimentation, and must have been laid down under different conditions. When, however, we come to Lower Miocene times the same type prevails over both areas, and when a volcanic bed is deposited, as in the case of the Parnell grit, it is deposited over limestones and sandstones alike. In other words, the conditions of deposit had become the same in both areas. This points apparently to a separation, in the earlier period, of the two areas, probably by a land mass; and there is some independent evidence for this. At Mount Wellington, a basalt puy, the Rev. Percy Smallfield found fragments of Maitai slate which had been erupted by the puy; so that the slates are probably at no great depth in this locality.

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* "Voyage of 'Novara,'" vol. ii.

† Q.J.G.S., 1885, &c.

‡ Part iv. of the "Palæontology of New Zealand."

§ See page 485.

|| See page 482.

¶ Geological Reports.

At Tamaki West Head, in the tuff (or volcanic neck?) of another basalt puy, large angular blocks of Maitai slates, quartzites, and phyllites occur. Lumps of Parnell grit have also been ejected. Some of the Maitai blocks are several feet in diameter, and the rocks must be quite close *in situ*. Farther east Motutapu is an island consisting mainly of Maitai slates. Much to the west, near the south head of the Manukau Harbour, Maitai slates have also been found. These points may be connected by an almost straight line, and, bearing in mind the lithological evidence and the fact that the Cheltenham breccia seems never to have passed this line, it seems reasonable to infer that in Oligocene times there existed a Palæozoic ridge or chain of islands, whose sunken summits are still traceable, which acted as a barrier to the western deposits. In Lower Miocene times it had sunk beneath the sea, and the Parnell grit spread over the whole area.

The fossil evidence for an Oligocene age is strong. The forms appear to me to represent a position somewhat intermediate between the Orakei greensand and the Papakura limestone; but, as the conditions were somewhat different, the Cheltenham breccia and Papakura limestone may really be contemporaneous. Below I give a list of the fossils so far obtained from the beds. Those marked with an "x" have not hitherto been named as occurring in them. I have not given in full the list of *Foraminifera* from Orakei, because the Cheltenham forms were not distinct enough to warrant identification. The *Barnea* from the Cheltenham bed I could not identify, nor was the Orakei *Barnea* identified by Mr. Park.

Name of Fossil.	Papakura.	Cheltenham.	Orakei.
Ostrea nelsoniana	x	..	..
Ostrea wallerstorfi	x	..	..
Terebratella cruenta	x	..	..
Waldheimia gravida	x	x	..
Terebratella dorsata	x	x	..
Rhynchonella nigricans	x	x	..
Cidaris sp. (corals)	x	x	..
Retepora beaniana	x	x	x
Pecten hochstetteri	x	..	..
Pecten burnetti..	x	x	..
Pecten fischeri	x	x	x
Pecten polymorphoides	..	x	x
Pecten zittelli	..	x	x
Pecten convexus	..	x	x
Idmonea giebeliana	..	x	x
Idmonea radians	..	x	x
Idmonea serialis	..	x	x
Idmonea inconstans	..	x	x

Name of Fossil.	Papakura.	Cheltenham.	Orakei.
Hornera pacifica	..	x	x
Hornera lunularis	..	x	x
Spiropira verticillata		x	
Spiroporina immersa ..		x	
Heteropora grayana ..		x	
Fasciculipora mammillata			
Fasciculipora ramosa ..			
Fasciculipora intermedia			
Celleporaria gambierensis			x
Celleporaria globularis ..			x
Escharifora lawderiana ..			x
Filiflustrella pacifica ..			x
Eschara aucklandica ..			x
Semieschanpora porosa ..			x
Biflustra papillata ..			x
Porina dieffenbachiana ..			x
Salicornaria margintata ..			x
Salicornaria ovicellosa ..			x
Filispara orakiensis ..			
Entotophora nodosa ..			
Cellaria punctata ..			
Crisinta sp. (Foraminifera)			x
Barnea sp. (Cerithium) ..			x
Hornera striata			x
Mesenteripora rerehauensis			x
Bidiastopora toetoeana ..			x
Entolophora haastiana ..			x
Sparsiporina vertebralis ..			
Crisina hochstetteriana ..			
Cellepora inermis ..			
Eschara monilifera ..			x
Flustrella denticulata ..			x
Flustrella clavata ..			x
Vincularia maorica ..			x
Melicerita augustiloba ..			x
Stegenepora atlantica ..			x
Vaginella			x
Turbo			x
Rissoa			x
Nucula			x
Leda			x
Cardita			x
Carduum			x
Dosinia			x
Turritella			
Ostrea			
Rhynchonella			

I have endeavoured to group them as far as possible so as to show the blending of the faunas of the first and third beds in the second. It will be seen that the Papakura limestone and the breccia have five forms in common, but the former bed probably contains more *Bryozoa* than *Retepora beaniana*, which may add considerably to the list. Twenty species of

Bryozoa are common to the greensand and the breccia. *Pecten fischeri* and *Retepora beaniana* are common to all three beds.

The stratigraphical and palæontological evidence are thus both in favour of an Oligocene age. There is evidence also in favour of the supposition that the breccia had its source in the Waitakerei vents; and, since those vents are considered Oligocene, such an origin for the breccia strengthens the above arguments.

My reasons for believing that the source of the Cheltenham breccia was the Waitakerei line of vents are briefly as follows: Firstly, the bed is Oligocene and the vents are Oligocene; undoubted Waitakerei breccias contain a fauna similar to that in the Cheltenham breccia; and the lava in the range is very similar to the lava in the breccia. Secondly, the Waitakerei vents are the only Oligocene vents not far from the breccia, which can be shown to have had a not distant source; and the bed grows coarser in this direction, but does not extend to the east. Thirdly, this supposition explains some anomalies in the distribution of the bed.

I have already given my reasons for considering the breccia Oligocene. With regard to the range I must rely on the observations of others, since I was not able, in the absence of roads and especially in the winter, to explore its forest-clad slopes for myself. The most important observations on the age of the Waitakerei vents are those of Mr. James Park.*

Mr. Park wrote that his work in 1886 tended to show that the Manukau (= Waitakerei) breccias "*originated during submarine volcanic outbursts of an intense character, some time during the deposition of the Orakei Bay beds, most probably at the horizon of the Parnell grit and Takapuna [= Cheltenham] ash-bed. At Komiti Peninsula, and further north, on the Wairoa, marine beds, containing characteristic fossils of the Orakei Bay horizon, are interbedded with heavy deposits of volcanic breccias, tufas, and agglomerates, and occasionally sheets of solid lava, consisting of dolerites rich in olivine, hornblende, and augite-andesites. These can be traced southward to the Hoteo and Kaukapakapa, and an examination of the bush country south of the latter will probably show that they are connected with the breccias of the Waitakerei Range."

The classing of the Orakei greensand, the Parnell grit, and the Cheltenham breccia as "Orakei Bay beds" is somewhat confusing, and I am ignorant as to what "the characteristic fossils" were to which Mr. Park refers; but, since the out-

* Trans. N.Z. Inst., 1889.

bursts were "most probably at the horizon of (the Parnell grit and) the Takapuna ash-bed," I infer that they were those species which are common to the Orakei greensand and the Cheltenham breccia—very probably *Pectens* and *Bryozoa*. I have not had an opportunity of examining the Waitakerei breccias, but I am informed that immense numbers of *Bryozoa* are found in them; and this is the most striking and characteristic feature of the Cheltenham breccia.

A description has already been given of the Cheltenham lava. Besides examining the slides of the Waitakerei lava in the Auckland University College laboratory, I made several myself from lava *in situ*, and found the lava very similar to that contained in the breccia. Naturally, all the outcrops of the bed are not likely to owe their origin to the same vents, since several vents along the chain were, no doubt, active simultaneously. Where, however, we can ascertain approximately the position of the vent from which the materials of the bed at any one outcrop were derived the lava *in situ* shows a striking resemblance to the lava in the bed, which is all we can expect. Till the Waitakerei eruptions have been studied, more than a general similarity need not be looked for. I may, however, give one case of more certainty, and therefore more interest.

The outcrop of the breccia at the White Bluff is not many miles from the range, and is, moreover, at the southern end of the chain, so that the southern vents may be considered as its source. In the bed there are several varieties of lava, but the commonest are—(1) A purple earthy rock with abundant phenocrysts of kaolin; (2) a black amygdaloidal rock with bright unaltered feldspar phenocrysts; (3) a dark-brown or chocolate rock of a somewhat holocrystalline appearance since the phenocrysts of feldspar are very numerous, and large black phenocrysts of pyroxene also occur. These three kinds of lava are found to be plentiful *in situ* in various localities between Big and Little Muddy Creeks, about six miles to the westward.

The Waitakerei Range is, moreover, the only chain of Oligocene vents near at hand, and the breccia cannot have come from a distance. The size of the included fragments, varying from 1 ft. to 4 ft. in diameter, is, it seems to me, conclusive. I have also found numbers of elliptical or round volcanic bombs, which are not likely to have come a great distance. The bed cannot often be seen in successive outcrops, each nearer than the last to the Waitakerei Range, but where this can be observed the nearer outcrops are always the coarser. St. Helier's Bay, for instance, is about twice as far from the vents as the White Bluff, and the coarseness at the latter is much more marked than at the former spot.

Lastly, such a source as I suppose explains anomalies of distribution which I shall now describe. Mr. Park wrote that the ash-bed had a linear extension from Parnell to Whangaparaoa Peninsula, thirty miles from Auckland, and I shall assume that the volcanic breccias of that peninsula are really extensions of the Cheltenham bed. In that case the coarsest outcrop of the breccia is at the White Bluff, but at Wairau the breccia is coarser than at Cheltenham, which lies midway between White Bluff and Wairau. Again, it is coarser at Deep Creek than at Wairau or Okura, yet Deep Creek lies midway between Wairau and Okura. Or let us consider the variations in thickness. At White Bluff it is 30 ft., at Cheltenham 25 ft., at Wairau 30 ft., at Deep Creek 40 ft., at Okura 4 ft., at Whangaparaoa 20 ft., each of these places being farther north than the preceding one.

It seems to me that these wide variations in both thickness and coarseness must be due to a variety of sources, in a chain of vents. Until we have far fuller fossil evidence than we at present possess it seems impossible, or at least inadvisable, to attempt to separate these beds, which we may judge from their coarseness to have all come from the Waitakerei vents, the fossils in the beds, from White Bluff to Onehunga, confirming this. To attempt the separation it would be necessary to know the position of the vents, of which we are quite ignorant. In the meanwhile we may group the beds together as the "Cheltenham breccia," regarding this really as a number of breccias formed at much the same time under much the same conditions, but derived each from its own vent or group of vents; for we know that the Waitakerei Range extends northward at least as far as Whangaparaoa, and that there are other andesitic volcanoes beyond that which may be of the same age. If we accept this origin for the breccia our difficulties vanish. The volcanoes of the Waitakerei chain were not equally active, equally powerful, or exactly synchronous. Some outcrops of the resulting breccias would be thick and coarse, others thinner and finer, while here and there breccias of different origin would be mingled together. Nor would the vents be quite in a line; some might be to the east of it, some to the west. Some would throw out mainly scoria; others, with greater explosive energy, would eject large blocks. The thickness would probably vary more than the coarseness, since no outcrops are far from the main line, and this we find is actually the case. I believe the Okura breccia may pretty safely be separated from the Cheltenham, but beyond that it is impossible to go; and perhaps it is better, on the whole, to use the term "Cheltenham breccia" for the present in the wide sense I have given to it.

The outcrops of the breccia at White Bluff and Wairau have already been described in sufficient detail. The other outcrops now to be described are as follows: (1) St. Helier's Bay; (2) Cheltenham and Narrow Neck; (3) Deep Creek; (4) Okura; (5) Whangaparaoa.

The outcrop at St. Helier's Bay is a reef, covered at high-tide, about 20 yards from low-water mark. It is a coarse bed, with large rounded and angular fragments, and contains *Pecten zittelli*, *Pecten burnetti(?)*, and *Bryozoa* too much weathered for identification.

Cheltenham Beach is the first outcrop north of the harbour, and is the typical one (Plate XXXVIII., fig. 2.) The bed has an easterly dip, and comes down along the face of the cliff, which extends at right angles to the above section. The breccia is thus exposed for several hundred yards. The cliff then again turns east and west, and at the head of the bay the dip has increased from 30° to 70°. Round the headland there is violent dislocation and a fault. Beyond this the sandstones show a beautiful example of a dome, the centre of which is at the middle line of the beach. A few hundred yards beyond, the north-westerly dip brings down a volcanic bed. This is much thinner than the bed at Cheltenham—only about a quarter of a mile distant in a direct line. It is, however, equally coarse, and I see no reason to suppose it to be a separate bed. The only fossils obtained were some weathered *Bryozoa*. This outcrop is very remarkable, owing to the fact that in the breccia as seen in the face of the low cliff there is evidence of very complete decomposition, while where it is exposed to the waves it is quite fresh and hard. At the former place it has weathered to a creamy white and is clayey to the touch; the lava is pale-grey, scarcely distinguishable from the matrix, and quite soft and rotten, so that the bed might be mistaken for a mudstone. As one follows it towards the water's edge it hardens and darkens, till at low-water mark it exactly resembles the outcrop at Cheltenham, the lava here being dark-grey or black, and giving a ringing sound when struck with the hammer, though at the cliff one may pull it to pieces with one's fingers.

Crossing the bay, along the shore of which there is nothing more than a bank a few feet high, the dip continues regular, till at the north headland the breccia is again met with in a long reef separated from the cliffs by a fault. It runs out into the sea for several hundred yards. I found no fossils except *Bryozoa*. It seems quite possible that the reef may be an extension of the fault. The outcrop at Wairau Creek has been mentioned in discussing the age of the bed. It is the next outcrop.

About seven miles from Wairau Creek there is another outcrop of the breccia. The strata near Deep Creek have a southerly dip, which brings up the volcanic bed at the south head of the bay. At the north head it forms the mass of the cliff, and also a small island 50 yards from the shore, which is completely composed of it. The actual thickness is nowhere seen, as a fault occurs beyond the bay, but the bed must be more than 30 ft. thick. It is rather coarser than at Cheltenham, and contains numerous *Bryozoa*. The weathering of the upper parts is very noticeable. The upper 8 ft. weathers to a rich red earth with concentric markings (Plate XXXVIII., fig. 3).

On the north bank of the Okura River there is an outcrop of a coarse volcanic breccia interbedded with shale and sandstone. In texture it resembles the Deep Creek bed, but it is not more than 4 ft. in thickness. The dip takes it up above the cliff-line. The Okura River forms a kind of V with the Wade River, the apex being directed seawards. On crossing the Wade River one is at the foot of Whangaparaoa Peninsula.

Whangaparaoa Peninsula, thirty miles from Auckland, is about thirty miles round. This journey had to be done in a day along a rugged coast, where it was sometimes difficult to get along the rocks, so that I had little time for observations. Unfortunately, too, being pressed for time, I omitted the end of the peninsula from the journey, and this apparently was the locality from which Hochstetter's section was taken. The cliffs on the south are composed of hard sandstones with layers of shale, and at intervals a volcanic breccia resembling in all respects the Okura breccia is interbedded with these. It is perhaps slightly coarser than at Okura, but the thickness is very regular—about 4 ft. The first point at which I observed it was in the cliff opposite Kohanui Island. Large blocks have fallen from the breccia, which lies on a shale bed about 30 ft. from the foot of the cliff. No doubt the shale has become slippery, allowing large blocks of the hard breccia to slide away and form an admirable protection at the foot of the cliff. The fragments of lava contained in it are a compact grey rock with feldspar phenocrysts. It is apparently an augite-andesite, and resembles fragments from Cheltenham breccia. At Korimai Bay there is a very similar outcrop of the same bed, and there are occasional outcrops of the bed on the northern shore, but part of this coast I examined in twilight. Along the beach I noticed occasional fragments, well water-worn, of augite-andesites.

Mr. E. Wilson informs me that at Mahurangi Heads, about ten miles to the north of the peninsula, there is an outcrop of a very similar bed; but it is coarser, lumps of lava

"from the size of an orange downwards" occurring in a "clayey matrix." Some of the fragments were forwarded to me. Most of these are augite-andesites, but one specimen appears to be a dolerite. The augite-andesites closely resemble the andesites in the peninsula breccia. I am informed that this coarse breccia is conformably overlain by sandstones, and may be traced seven or eight miles farther north, cropping out at Omaha and Matakana.

In addition to these coarse beds, I observed in the cliffs of the peninsula ash-beds of a much finer grain, not unlike the Wairau tuffs.

In conclusion, I add Hochstetter's remarks on this locality: "The peninsula of Whangaparaoa, which I visited from Auckland, consists principally of the same Tertiary strata which constitute the isthmus of Auckland. The steep cliffs in the hills show the horizontal strata clearly exposed: at the bottom generally fine-grained sandstone in layers 6 ft. to 8 ft. thick, and over these a thin stratum of clay marl. Very frequently there are intermediate strata of volcanic tuff, which is partly developed as a fine-grained sandstone, and partly coarse-grained as a breccia, consisting of fragments of trachyte, dolerite, and basalt. At the places where coarse-grained breccias and conglomerates appear very striking local disturbances of the strata are noticeable. A very instructive section is afforded by the north (north-east?) shore of the peninsula.* *a* is a tuff mass showing in places a very coarse-grained conglomerate of fragments of volcanic rocks, and containing much augite in little shining crystals, and, besides augite, little twin crystals of glassy triclinic felspars. This mass appears as an eruptive formation which has penetrated between the sandstones *c* and clay-marl *d*, torn them asunder, broken them by lateral pressure to the westward, and forced them out of their original horizontal position. At *b* the tuff is fine-grained, and in places full of *Foraminifera* and *Bryozoa*. A smooth *Terebratella* (*Waldheimia lenticularis*) was also found here enclosed in the tuff, so that there can be no doubt we have in these volcanic tuffs the products of submarine eruptions, with which the volcanic outbursts commenced in the Tertiary period."

I have quoted this passage at length, because it gives so admirable an illustration of the manner in which these Tertiary breccias may be distorted. An equally good example will be given when the Parnell grit is described. Hochstetter does not attempt to explain how the volcanic breccia was injected, and I am at a loss to explain it.

From the description of this bed, and its contained fossils,

* "Reise der 'Novara,'" quoted in Geol. Surv. Repts., 1885, p. xxxvi.

and my own examination of the peninsula breccias, I cannot but think that, though these are doubtless outcrops of a volcanic bed which owed its origin to Waitakerei Oligocene vents, those vents were not identical with that which produced the Cheltenham breccia. Probably it was equally near (for the lava fragments are quite as coarse), but from the thinness of the bed one is led to infer that the vents which formed it were smaller, or that they continued active for a comparatively short period.

The Parnell Grit.

The Parnell grit, like the Cheltenham breccia, presents a somewhat bedded appearance, due to the linear arrangement of fragments of similar size. In this case, however, the bands are much more regular, and the coarsest fragments—the size, perhaps, of marbles—are all at the bottom, from which point the bed grows gradually finer till it shades off into a sandstone. The outcrops of the Parnell grit everywhere present the most beautiful examples of the shading-off of one rock into another. The red rounded lapilli of the lowest layers are gradually replaced by smaller ones, and these by yet smaller, till at length they can no longer be observed with the naked eye, and on a fresh fracture the rock has all the appearance of a blue sandstone; nor is it possible to say where the sandstone begins and the breccia ends. The lapilli are very uniform in size in each layer, which seems to indicate a distant origin. The average thickness of the bed is about 18 ft. Fossils do not seem to be as abundant as in the older beds.

The weathering is extremely characteristic and useful. In the coarser parts it is similar to that of the Cheltenham breccia, but in the upper parts concretionary or spheroidal structure is usually developed. Round the shells of brown iron-oxide the dark colour which the bed usually presents is absent, so that the concentric layers are plainly visible. This type of weathering seems to be almost confined to this bed, none of the Waitemata sandstones exhibiting it; and it is invaluable as a means of detecting the presence of the bed in inland outcrops, where the colour has generally all been leached out and the bed is left an (apparently) white crumbly sandstone. Under sea-water neither this bed nor the Cheltenham breccia weathers more than a few inches, and the feldspars remain comparatively fresh.

As at Cheltenham, a very common feature of the bed is the occurrence of zeolite "dykes," dividing the surface of the grit into irregular polygonal plates. These dykes, when split, frequently show beautiful dendritic manganese markings. The markings closely resemble those formed by moist emery-

powder when, after grinding a section, one slowly withdraws the slide at right angles to the iron plate, the markings occurring both on the plate and on the slide. Possibly the dendritic markings on the zeolites were formed in an analogous manner.

The lava fragments are so small and so oxidized that I was not successful in making any microscopic sections. My sections of the grit were scarcely more successful, the rock crumbling away before it was thin enough to be of much service. In one or two instances fragments of lava could be recognised in the sections, containing feldspar and six-sided augite phenocrysts and probably an augite-andesite.

Among the crystals in the tuff corroded quartz grains occur, which may be due to the mingling of sandy sediment, or, since Sir James Hector says that the grit contains fragments of trachytes, may be derived from them or from more acid rocks. By far the most numerous crystals are small oblong feldspars sometimes altered and milky, at other times fresh and bright, with good cleavage. These are very plentiful throughout the bed. A few broken fragments of augite crystals are also present, but the large perfect augites described as occurring in the Cheltenham breccia are conspicuous by their absence. The grit is largely composed of fragments of greenish sandstones and slates which may be Palæozoic rocks. Large blocks of sandstone are absent, and current-bedding is unusual. Iron-pyrites is plentifully disseminated in bright-yellow flecks. The black matrix is often studded with scarlet scoria and white feldspars, and forms a handsome rock. From the plentiful occurrence of feldspar and augite the grit may be best described as an augite-andesite tuff.

I do not consider the source of the Parnell grit by any means as certain as that of the Cheltenham breccia, but, on the whole, the evidence is perhaps in favour of a source near Cape Colville. Before giving what evidence there is in support of this I must freely admit that the grit may have come from the Waitakerei vents, like the other volcanic beds of the series. But in the first place it is a good deal younger than the Cheltenham bed, as is shown by the fact that it crosses the Maitai ridge, which apparently was above water when the former bed was deposited; and so it is quite possible that the Waitakerei vents may have become quiescent. In the second place, it is a bed with a very wide distribution, extending from Ponsonby to Turanga Creek, from Manukau to St. Helier's. Yet it is not a coarse breccia. Such a widespread bed must have been, one would think, the result of very violent eruptions, and if the eruptions at Waitakerei were very violent the bed at the Manukau ought to contain some

coarse lumps. But, if it came from Coromandel, a great outburst might result in just such a bed at so considerable a distance. In the third place, it grows coarser, on the whole, in an easterly direction. At the Manukau the bed at the White Bluff, though evidently the same, is yet rather finer than at St. John's, to the east. I cannot say that I have observed any increase of coarseness between Ponsonby and Parnell, but between Parnell and St. John's College there is a distinct increase. At Tamaki Head the bed is coarser than at St. John's, while the outcrop in the reef is, on the whole, intermediate between the two. It is very noteworthy that Mr. Park was so struck by the increase of coarseness at Howick that he described the bed there as "much coarser" than at Parnell. Had he seen the outcrops at St. John's, St. Helier's, and Tamaki Head he would hardly have noticed the increase, so gradual is it; but it becomes noticeable when we compare places far apart. Ponsonby is eight or nine miles from Howick. At a spot between Little Muddy Creek and Avondale I found what appeared to me an outcrop of the Parnell grit. The bed weathered in concretions, and was, as usual near vegetation, leached of its colour, and crumbly. It was much finer than near Auckland, and only 10 ft. thick, and the sandstones with which it was interbedded seemed to be lying on Waitakerei lavas, but this I could not decide. It is so like the usual outcrops of the Parnell grit that I see no strong reason for doubting its identity. If this be accepted, the Parnell grit evidently did not come from the Waitakerei vents; and I think the evidence from coarseness is entirely in favour of its having come from the east, not the west. Lastly, we have the opinion of so excellent a geologist as Sir James Hector, already quoted: "The Parnell grit, as far as I have seen, contains no fragments of the volcanic rocks of the district, but is greensand, with well-rolled pebbles of cherty slate, quartzite, and other Palæozoic rocks, and occasional fragments of old trachyte and basic rocks of Cape Colville." I might add that the volcanic inclusions are invariably in the form of lapilli, full of steam-vesicles, such as one would expect to have come from a considerable distance.

The age of the Coromandel volcanic gold-bearing series is a matter of dispute; but Mr. Park, who has studied them, is evidently convinced that they are about the same age as the Parnell grit. He had in 1889 placed the grit in the Upper Miocene, but for some reason he changed his mind, and wrote in 1897: "Judging from the fossiliferous Parnell bed in the Upper Eocene Waitemata marine series, on the shores of the Waitemata, with its contained fragments of andesite and coarse ash, the author is of opinion that the eruptions which originated these gold-bearing rocks began in the Upper Eocene

and continued down to the Lower Miocene period." In my opinion, Mr. Park is here confusing two beds; but, be that as it may, he seems to consider that the Coromandel Peninsula eruptions began at the horizon of the Cheltenham breccia, but lasted for a long while, and this is all that is required in the supposition that the Parnell grit came from Coromandel.

Its Age.

The most interesting question relating to the Parnell grit is its stratigraphical position. Most observers have supposed that the grit overlies the Orakei greensand, but apparently on no very good evidence. Captain Hutton contributed a paper in 1884 to the New Zealand Institute in which he concluded that the relative position of the beds was uncertain, and he even wrote: "To the east of Parnell, between Resolution Point and Hobson's Point, there is a break across Hobson's Bay in which nothing definite can be seen. It is therefore quite impossible to say from stratigraphical evidence whether the beds at Hobson's Point are above or below the Parnell grit.* It is not really at all impossible, and it seems to me that Captain Hutton implied as much when he assumed that the Hobson's Point fossiliferous greensand is an extension of the Orakei bed. No one doubts this; but it is evident that if the greensand may be traced from Orakei to Hobson's Point it may be traced farther, and thus new evidence may be supplied. The Parnell grit may also be found cropping out farther east. As a matter of fact, both the greensand and the grit do occur at many localities eastward.

Before giving this new evidence it will be well to review Mr. Park's opinion, which was the reverse of that here adopted. Considerable support is given to Mr. Park's opinion by the sections which he published, but I am unable to agree with Mr. Park's interpretation of the stratigraphy. The dips are, in my opinion, sometimes the reverse of those given by Mr. Park, who wrote in 1889†: "As bearing on the relation of the Parnell grit to the Orakei Bay bed, I may mention that during my last visit to St. George's Bay I found a number of Orakei fossils in the flat irregular calcareous gritty cornstones at the foot of the cliff on the west side of the bay. These cornstones are only exposed at low water, and occupy a position some 15 ft. or 20 ft. above the Parnell grit. The fossils collected at D were *Pecten fischeri*, *Vaginella*, *Orbitolites*, and a number of small corals. The occurrence of Orakei Bay fossils in this position would tend to show that the Parnell grit is inferior to the Orakei Bay beds; but, if the

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* Trans. N.Z. Inst., 1884.
† Trans. N.Z. Inst., p. 399.

evidence is not sufficient to prove this, it shows that these two horizons are at least not far separated from the Orakei greensand."

Now, in the first place, *Pecten fischeri* might occur at any horizon from the Oligocene limestone at Papakura to the Miocene greensand at Orakei, if it has not a greater vertical range. But, be that as it may, I cannot agree with Mr. Park that the Parnell grit underlies the cornstones, as shown in his section.

Mr. Park was of opinion that the bed could be seen dipping under the Mechanics Bay beds; but, although the grit may certainly be seen in the floor of the bay, I think that a fault separates it from the beds at Mechanics Point. This fault dips, I believe, as Mr. Park's section shows it (only the plan can actually be seen), but I would make it a normal fault, Mr. Park a reversed one; and, in my opinion, the grit is superior to the Mechanics Bay beds.

But the most important point in which I differ from Mr. Park is the amount and direction of the dip at B in his section. A photograph was taken for me, which shows that the dip is a low westerly not a high easterly one.

Mr. Park shows another section of less importance at Hobson's Bay, where, again, I must differ from him, not as regards the amount of dip so much as the direction, which here, again, I consider to be the reverse of that given in his section.

At Hobson's Bay, however, there is no fossil evidence, and the dip which Mr. Park gives to the grit is suggestive of a position inferior to the Orakei greensand at C of his section, but only suggestive; and Mr. Park did not seek to establish that position from this section.

My observations do not prove that the Parnell grit lies above the Orakei greensand, for there is a mile of mud-flat (covered at hightide) between Morrin's Point and Resolution Point. If this were all the evidence a superior position for the Parnell grit would be only suggested; the fuller evidence lies to the east, where both the grit and the greensand may be followed for several miles.

Mr. Park found a bed "resembling" the Parnell grit at Howick, but apparently doubted the identity. He says it is coarser; so that the grit seemed to him to get coarser in two opposite directions—Cheltenham and Howick. Besides, he found "lumps of limestone" at the base of the bed, and thought it Kaipara limestone. Kaipara is to the north-west, very much nearer the grit at Parnell and Cheltenham than at Howick, so that it was difficult to see why the limestone lumps were not at the former places, although found at Howick.

Except for this notice the Parnell grit has not hitherto

been described to the east of Point Resolution. I have been successful in finding seven new outcrops in this direction, and they supply a good deal of new stratigraphical information. Some hitherto unrecorded outcrops to the west are also full of interest.

Round Point Resolution the cliffs grow low, and are covered with scrub. Here and there, however, an outcrop of the strata may be seen along the cliffs to Newmarket. The beds all have a westerly dip. Not far from Newmarket the Parnell grit can be seen, so that it is apparently well above Morrin's Point beds here, and rising in that direction.

Leaving this doubtful locality, we come to outcrops where the evidence for a superior position is more important. There is, near St. John's College, a very fine exposure of the Parnell grit. The College itself stands on a high ridge 300 ft. above the sea. Numerous small streams have cut their way down in a north-westerly direction to the old crater-lake of Orakei. The chief stream rises at the College, and, cutting down through shales and yellow sandstones, which are dipping as the bed of the stream, but at a lesser angle, reaches the Parnell grit. Here there is a considerable waterfall: the underlying shales have been eaten away much more rapidly than the hard volcanic bed. It is at this waterfall that the grit is so well exposed. It is from 15 ft. to 20 ft. thick, and rather coarser, in the lower parts especially, than at Parnell. There is a large amount of iron-pyrites in it, and very numerous laths of feldspar. I could not find any fossils. The grit is overlain by the yellow-and-white sandstones, and overlies conformably, with no sign of current-bedding, a layer of shale. Beneath this is a calcareous grey sandstone, very hard and full of fantastically shaped concretions. In the concretions of a very similar sandstone at Kohimarama I obtained some well-preserved lamellibranch shells, about the size of *Venus*, which I have not been able to identify. These sandstones are at about the same horizon.

Plate XXXVIII., fig. 4, shows the position of these beds. At 4 in the section occurs the waterfall; the stream has cut right through the grit here, just before the latter rises north-west. The outcrop between A and B is not easy to find. It may be seen in a well close to the Presbyterian Church. There is one break in the section, at 5, where a modern tuff volcano has covered the beds and distorted them close to the point of eruption. I do not think, however, that this eruption disturbed the general dip of the beds. The Orakei greensand should come in between beds 2 and 4. Everything there is covered with very dense gorse. The Wairau tuffs are seen in the bed of the creek when the tide is out and a freshet has scoured away some of the mud.

I examined the Orakei tuff to see whether it would throw any light on the question. It is chiefly composed of fragments of basalt (Mr. Park mentions trachyte; I could only find hard black scoriaceous lava, with olivine), but here and there are fragments of grey sandstones and shales, and occasionally of the Wairau tuffs. There are no fragments, as far as I could see, of the Parnell grit. If this thick bed had been below the Orakei greensand, fragments would in all probability have been thrown out. A beautiful illustration of such an event occurs in the case of a similar outburst at Tamaki Gulf, where a modern volcano has broken through the Parnell grit and contains large fragments of it scattered everywhere through the tuff. The Parnell grit is an easy rock to recognise, and as it is hard it would not be blown to dust if the Wairau tuffs escaped. But fragments of these tuffs are included. Now, these are below the grit, so that the grit was, no doubt, all denuded away before the outburst—at least, that portion of it above 5. In that case it must have been at a good elevation, and therefore probably above the Orakei greensand. It was at C that Hochstetter collected from the greensand.

The outcrop of the Parnell grit, forming a reef in the harbour near the Bean Rock Lighthouse, throws no light on the stratigraphy.

The next outcrop is at the west head of the Tamaki. Before referring to this it will be advisable to trace the Orakei greensand in the same direction. At the bridge which crosses the outlet of the sunken Orakei crater to the sea the rocks exposed in the low cliffs are the Orakei tuff beds. These are seen a little further on to be quite unconformable to the Waitemata sandstones. Interbedded with these is the Orakei greensand. Here it is a greenish sandy bed which thins out completely in both directions—a lenticular mass; but it appears again at a little distance on both sides. This patch is the most fossiliferous outcrop, yielding more than forty species of fossils in a few yards, though the bed is only a couple of feet thick. Proceeding round the cliffs towards St. Helier's Bay the bed is next seen, beyond a fault, as a reef separated from the shore by 30 yards of deep mud and covered at hightide—here, again, richly fossiliferous. A little beyond the west head of Okahu Bay the strata have a westerly dip, which brings up the greensand in a gentle slope across the face of the cliff. *Pecten zittelli*, *Pecten fischeri*, Gastropods, and *Bryozoa* are the commonest forms contained in it. A fault exists in the middle of Okahu Bay, or the dip changes, for on the east side of the bay the bed is seen dipping easterly, and is again seen at the Bastion, where it has an easterly dip and passes down below the water. From this point to Tamaki West Head I

have not observed any outcrop, so that I cannot say with certainty that the beds are identical. I think, however, we may fairly assume that they are. The lithological characters are the same, and peculiar to these beds; both are somewhat gritty greensands with small red patches of volcanic fragments. The fossils at the Tamaki Head bed are *Pecten zittelli*, *Pecten fischeri*, and most of the Orakei *Bryozoa* named by Hochstetter in the "Voyage of the 'Novara.'" The bed can be seen at intervals along the cliffs of the Tamaki Gulf, till towards Panmure we reach pumice sands unconformable to the Waitemata series. In these outcrops I have only found *Bryozoa*, but they are much more numerous than at Orakei even, though the same species.

I have given a somewhat full description of this bed—First, because it is, so to speak, a central line in the Waitemata beds from which other horizons may be worked out; and, secondly, because, though it is undoubtedly best described as a sandstone, it yet contains volcanic fragments, and is therefore connected with the volcanic beds of the Waitemata series.

At Tamaki West Head occurs one of the most interesting sections in the vicinity of Auckland. It is interesting from several points of view. In the first place, it supplies a section in which the Parnell grit and the Orakei greensand both occur, and is the only section I know of in which they do. It is also the spot whence Major Heaphy's section was taken, a section which has since appeared in most text-books on volcanoes. Moreover, it is in this locality that the volcanic neck(?) occurs, with large blocks of Maitai slates and quartzites.

Mr. Park has given a section of this most interesting locality.* Here, again, however, I am not able to agree with him regarding the dip of the beds at the west head. A photograph kindly taken for me by Mr. W. Satenby will exemplify my views. Mr. Park, moreover, omits from this part of his section the most prominent bed, the Parnell grit, and also the Orakei greensand. On the western part of his section he omits the high sandstone cliffs, and therefore, of course, the Parnell grit. He also writes that the beds are "undulating gently"; but, in my opinion, this is one of the most contorted spots on the whole isthmus.

In Plate XXXVIII., fig. 5, A on the section is the Tamak West Head, B a bluff not far from St. Helier's Bay. At C there is distortion and small anticlines, not shown in the section because they are on a small scale though very perfect. 1 is the Parnell grit, 2 the Orakei greensand, 3 sandstones and shales (but the beds are more numerous in the actual section), and 4 a recent tuff crater. This section is an extremely

* Geological Reports, already cited.

interesting one. It is said to be the one drawn by Major Heaphy* to show the strata through which a vent is forced, dipping down towards the vent. If it is the same, denudation must have been very active, since the crater is gone and the levels altered. I know, however, of no similar section in the Auckland cliffs, and the blocks shown in Judd's "Volcanoes" present much the appearance of the great blocks of Maitai and Parnell grit and sandstone which have been emptied at 4, or perhaps are the relics of the agglomerate in the old volcanic neck. 4 is the tuff. Numerous landslips have occurred here, obscuring the relations between the more recent tuff and the Waitemata beds. A plan of this tuff cone is given by Hochstetter.† It forms a beautifully stratified cone, each layer composed of basalt fragments in a clayey matrix; and, as already mentioned, the agglomerate of the old neck(?) consists largely of green Maitai slates and phyllites often siliceous, and Parnell grit. There can be no doubt that the basalt vent burst through the grit. This forms a reef parallel to the shore opposite the cone, and at A the reef has curved round to the shore and dips up towards the cone. The chief interest in the section, however, lies in the fact that here at last we have the grit and the greensand together. But, unfortunately, even here their relation is obscured.

Near B the grit is quite white and crumbly, but weathers in characteristic spheroidal fashion, so that it can easily be recognised from below. Near A I am at a loss to account for the appearance of the beds. Just below the grit is a sandstone, and the grit seems to lie unconformably on this sandstone, which is several feet thick at the first fault, and thins quite out at the second. Stranger still, though the greensand is lost at the fault, and, so far as I have seen, does not appear below the grit towards B, at A the grit passes right over the fault without any dislocation, and, rapidly increasing in dip to over 50°, passes down to the sea round the head. The only explanation I can give is that the eruption has driven the harder bed over the softer ones for some distance. The objection to this supposition is that, although the appearance in the section seems to fit in with it, just round A the grit seems quite conformable to the underlying sandstone, which in turn is only a few feet about the greensand. But I think such a position for the grit impossible, for then at Orakei we should see it above the greensand, while at Parnell we might expect to see the greensand below the grit. As we do neither there must be a considerable thickness of beds between them —at least 50 ft., I should say—and the appearance beyond A

* Judd: "Volcanoes," p. 165.

† "Voyage of the 'Novara,'" vol. i., Geology.

must be deceptive. However we explain matters, it seems certain, at any rate, that the grit is above the greensand. It is, perhaps, possible that this bit of the sea-floor was above water for a short time in the Miocene period, and that the grit is really unconformable; but I am inclined to think the explanation lies in the proximity of the basalt vent.

The grit forms the face of the cliff round the point, and this is probably one of the best places near Auckland for seeing its structure. The zeolite veins are well developed in particular. The fault is only inferred from the horizontal position of the sandstone at B, as landslips have covered the face of the cliff.

There is one other spot at which light is thrown on the relative positions of the grit and greensand—Maungamaungaroa Bridge. Mr. Park concluded from the fossils found here that these greensands were the equivalent of the Orakei greensand. I do not know at what spot exactly Mr. Park found these fossils, but interbedded with yellow sandstones and shales, and above the greensands, occurs an outcrop of the Parnell grit, very much weathered and easy to miss, containing *Fasciculipora ramosa.*

It may, then, be considered as highly probable that the Parnell grit is above the Orakei greensand, and even probable that it is considerably above. This fixes the age of the grit, since by a consensus of opinion the Orakei greensand is classed as Miocene, the Geological Survey alone considering it earlier.

Professor Rupert Jones, who examined the *Foraminifera,* thought them to indicate a "late Tertiary age" for the bed.

Herr Karrer, in the palæontological section of the "Voyage of the 'Novara,'" made the bed the equivalent of the Vienna basin—*i.e.*, Miocene.

Professor Martin Duncan identified them with the Mount Gambier series in Australia—Miocene.

Professor Hutton, the first of New Zealand palæontologists, examined the evidence generally, and came to the conclusion "that the evidence, both stratigraphical and palæontological, is altogether in favour of the Orakei Bay beds belonging to the Pareora system."

Since these beds are almost universally classed as Miocene, and from the Papakura limestone to the highest Waitemata sandstones the series apparently has no break, the greensand may fairly, I believe, be put at about the middle of that series. In that case the Parnell grit is Upper or Middle Miocene.

In dealing with the source and age of the grit I have already had occasion to describe some of the outcrops.

These I shall not again refer to. The following is a list of the outcrops: (1) Shelly Beach, (2) St. George's Bay, (3) Judge's Bay, (4) Newmarket, (5) St. John's College, (6) St. Helier's Bay, (7) Tamaki West Head, (8) Howick, (9) Maungamaungaroa Bridge, (10) White Bluff, (11) Cape Horn, (12) Little Muddy Creek, (13) Point England, (14) Blockhouse Bay(?).

At Shelly Beach the grit forms a synclinal. It has been described by Mr. Park, and I have nothing to add except with regard to the fault on the east of the section. I do not feel at all sure that this fault dips easterly, but I could not see the line of fault, owing to landslips and the fact that the bank is not high at Shelly Beach Road.

At Acheron Point, half a mile to the east, occurs the Ponsonby tuff. To that bed the dip is regularly west, so that there is at least 100 ft. of strata above the Ponsonby tuff at Shelly Beach. Now, the stratigraphical relations of the Ponsonby tuff are very puzzling, but it will be shown later that it is probably a little above the Cheltenham breccia, and therefore much below the Parnell grit. But here, if the Parnell grit is above it, it must be at least 100 ft. above. I see no objection to this, and am therefore inclined to think the Parnell grit is above the horizontal strata which form the Auckland hills, near the wharves, at Freeman's Bay, Hobson Street, Fort Britomart, and Mechanics Bay. Mr. Park strengthened this supposition by finding a few fossils, also found at Orakei Bay, in the Mechanics Bay bed. Both Professor Hutton and Mr. Park, however, believe that the grit overlies these beds.

Round St. George's Bay the grit dips under the sea. On the west of the following bay (Judge's Bay) the beds are much contorted. A section is given by Hochstetter. On the east of the bay the Parnell grit is beautifully exposed. This is the best locality for seeing the gradual shading-off of the coarser grit into a blue compact sandstone. Blocks have fallen from all parts of the bed, and every variety of texture may be observed. There are numerous zeolite veins running across the bed.

The next point at which the grit occurs (omitting places already described) is a reef not far from the Bean Rock Lighthouse. At the lighthouse itself the rocks are scoriaceous Auckland basalt. This cannot, I think, be derived from the North Shore puys or Rangitoto Island (a basalt volcano), since there is a deep channel between in each case, so that it probably marks the site of an ancient puy, perhaps a submarine one; but more likely its present position is due to the submergence of the old Waitemata River, which has led to the formation of the Waitemata

Harbour. This puy stood, perhaps, on the bank of the river near its mouth.

About a quarter of a mile to the east and nearer the shore a long low reef is exposed, which I visited in a boat, with the object of seeing whether the outcrop of the Cheltenham grit was here. The reef proved, however, to be the Parnell grit, lacking, as usual, coarse fragments, and unfossiliferous except for a few *Bryozoa*, which my friend Mr. E. K. Mules discovered, but which were too weathered for identification. There is a second smaller reef parallel to the first and only a few yards distant. The second reef is probably only another part of the grit. This outcrop of the grit is about as coarse as that at St. John's College.

The next easterly outcrop is at Howick. The Tamaki Gulf is crossed by a bridge at Panmure, about three miles from the mouth. Crossing this bridge, and making for a point near the mouth, it is easy to miss a long headland of cliffs which forms the east head of the gulf. Viewing this headland from the terminus of the road, it seems a small one, and the strata appear horizontal, so that Mr. Park, observing it doubtless from this point, wrote that the strata "are horizontal to the Tamaki, and consist of sandstones." I fell into precisely the same error, and it was not until several weeks later that I had an opportunity of seeing the real extent and position of the beds from the harbour. Unfortunately, I was too far distant to make exact observations, and I was not able to revisit the spot, but it was evident that not only are the beds much disturbed, but that at intervals there occurs a bed much resembling the Parnell grit.

Beyond the bay to the east of these cliffs occurs an undoubted outcrop of the grit. Mr. Park, who examined the same bed rather farther along, says that it is coarser than the Parnell beds, and "contains lumps of limestone in its lower parts." It certainly is coarser than the grit at Parnell, but very little coarser than the grit at the other side of the Tamaki, which Mr. Park did not observe. It is about 20 ft. thick, and traversed by veins of calcite. These in places have thickened into lumpy masses, and have fallen frequently in this form to the foot of the cliff, and are possibly what are described as "lumps of Kaipara limestone." In some places the veins are beautifully crystalline, containing large crystals of calcite in dog-tooth spar form. At other times the calcite crystals are small (requiring a lens to distinguish their outline) but very numerous, and forming a white sparkling surface to the black grit.

The grit lies in all places conformably on the underlying sandstones, and is also overlain by sandstones in a per-

fectly conformable manner. The first outcrop, however, occurring at the end of the bay, is a most peculiar one. The grit thins out abruptly. This appearance is due, I believe, to currents, which have produced "contemporaneous erosion," and is not an example of "current-bedding."

The thickness is about 15 ft., but apparently the bed thins out abruptly. This strange resemblance to an injected lava (there is, however, no alteration, of course, of the surrounding beds) is frequently found in outcrops of the Cheltenham breccia, but not so frequently in those of the Parnell grit.

Sir A. Geikie, who gives a similar section, writes: "It shows a deposit of shale which, during the course of its formation, was eroded by a channel into which sand was carried, after which the deposit of fine mud recommenced. . . . It is evident that erosion took place, in a general sense, during the same period with the accumulation of the strata. . . . We may reasonably infer that erosion was due to the irregular and more violent action of the very currents by which the sediment of the successive strata was supplied."

There is an example of "injection" in the Ponsonby tuff which cannot be explained by current-bedding, as will be seen later; but current-bedding is sufficient explanation of many of these unconformable appearances.

From Howick to Turanga Creek there is no outcrop of the grit along the cliffs. At Turanga Creek the greensands were found by me resting unconformably on Maitai slates, without any Papakura limestone between the two.

Along the cliffs of the Manukau Harbour the beds, as a rule, are almost horizontal. In places, however, they have been inclined at high angles, and here and there much disturbed. It is generally at these spots of distortion that the volcanic beds crop out.

There is a wharf about a mile or a mile and a half from Onehunga. At low water more of the grit can be seen, as it forms the base of the cliffs between the fault and the White Bluff. Round the White Bluff the Parnell grit rises somewhat steeply; but that section has already been drawn and described in dealing with the question of the identity of the two breccias. The Parnell grit is here about 12 ft.–15 ft. thick, and it is not as coarse as in the eastern outcrops.

About two miles beyond the bluff the Parnell grit is again met with, and may be followed for some distance along the base of the cliffs round Cape Horn, where its hardness has been of great service in protecting the cliffs from the effects of marine denudation (Plate XXXVIII., fig. 6). The section shown in fig. 7 is taken about three miles from Little Muddy Creek, where the last section of the grit to the

west was observed. The dip of the sandstones near 2 is not actually seen. The grit here is about 8 ft. thick. Lapilli, however, are rare in it, and in some respects its general appearance does not resemble that of the grit. This may be due simply to the fact that it is a very westerly outcrop. On the other hand, it is possible that the bed seen here is a distinct one, possibly an outcrop of the Ponsonby tuff, to be presently described.

7. The other Volcanic Beds.

Having dealt at length with the Cheltenham breccia and the Parnell grit, something must be said of the other volcanic beds. I have already said that I do not consider the coarse breccias containing *Bryozoa* as all identical beds, but find it impossible at present to distinguish between them. The finer tuffs of the same, or nearly the same, age may, however, be separated. Two of them are here described as the Wairau tuffs and the Ponsonby tuff. I should also mention that other beds contain occasional volcanic fragments, but not enough to constitute them tuffs. The Orakei greensand is a very good instance, for in that bed patches of scoriaceous lava the size of a pin's head may be detected with a lens. On the shores of the Tamaki, near Panmure, there are also pumice sands, but I believe these are Pliocene or later beds, unconformable to the Waitemata series, and derived from the pumice plateau in the centre of the North Island.

The Waitakerei breccias and conglomerates on the west coast and therefore on the other side of the vents, I have not visited; but they must, I believe, be classed with the Waitemata series.

It is interesting to compare the Wairau tuffs with that formed at the eruption of Tarawera. Except that the former were submarine, the resemblance is considerable; but, judging from their thickness and distance from the vent, the eruptions which produced them were larger. It is interesting to note that there are three or four tuffs separated in each case by a few inches of shale, so that the eruptions succeeded each other at only short intervals. These eruptions took place some time after those which produced the Cheltenham breccia, and were not, apparently, so violent.

Wairau Tuffs.

I have given this name to volcanic beds which are best developed at the Wairau Creek, near Lake Takapuna. There are really several beds, each separated from the next by a thin layer of shale. The distinction between a tufaceous sandstone and a sandy tuff is not very easy to draw, and some of these beds are decidedly sandy. The lowest, however, is

distinctly volcanic, with, occasionally, fragments of scoria as large as a pea.

The position of the Wairau tuffs appears to be above the Cheltenham breccia and below the Orakei greensand. I am uncertain whether they are above or below the Ponsonby tuff, since they seem everywhere to be above it; but at Ponsonby, where the section is clear, either they are not above it or they must be more than 100 ft. above it, a most unusual position.

The group of tuffs is more sandy than the Parnell grit, but the scoria can easily be seen with a lens. At the Wairau Creek I discovered a fragmentary Gastropod shell near the base of the second bed. It is very minute, not as large as a pea, and several whorls are evidently missing; but I believe it is a species of *Littorina*. Elsewhere I have not been able to detect any fossils.

Since there are no fossils, it will be advisable to give the reasons for identifying volcanic beds at Howick, St. John's College, the Tamaki, and Manukau Harbour, with this bed at the Wairau. In the first place, the beds do not resemble the ordinary Waitemata sandstones, which are blue or grey, while these tuffs are brown or black, with a tendency sometimes to spheroidal weathering. In the second place, although there is a little scoria present occasionally in other beds, it is never so abundant. In these beds, too, occur veins of calcite, with large crystals sometimes ½ in. long (dog-tooth spar); and there are also veins of zeolites. And, moreover, these beds always occur as a well-defined group of black bands in the cliff, the lower being the more tufaceous.

At the north head of Castor-oil Bay the tuffs are separated by bands of sandstone, as at St. John's College. Generally they are separated by thinner layers of shale.

In the first section I observed the bed was about 8 ft. thick. Across Castor-oil Bay no section can be seen, the ground being low. In the floor of the bay nothing can be seen, owing to the covering of yellow sand. If there is no break—and there is no reason to suppose one—the Wairau tuffs are here about 30 ft. above the Cheltenham breccia.

To the north of the Wairau (Castor-oil Bay) I saw nothing of the tuffs, but some of the finer tuffs at Whangaparaoa resemble them.

On the southern side of the harbour there is no outcrop of the tuffs until St. John's College is reached, the reason being that younger beds occur along the cliffs. At St. John's College they are seen in the floor of the stream when the tide is out and a freshet has scoured away the mud. The bed of the stream is obscured farther up by a raupo swamp, and the hillsides are thickly covered with gorse. Wherever the strata can be seen they are, however, sandstones, so that it seems

fairly certain that the Wairau tuffs are here about 70 ft. below the Parnell grit, which coincides with the supposed general position of the beds. The tuffs are more sandy and thinner than at Wairau.

The Wairau tuffs occur at the Tamaki, near the west head. Apparently they are above the Orakei greensand, but faults make it impossible to say with certainty.

At Howick the Wairau tuffs again crop out, this time in numerous thick bands separated by several layers of shale, and shading off into sandstones. Here they are traversed by numerous zeolite veins. They occur not far from the last outcrop along Howick cliffs of the Parnell grit, but the relation between the two is obscured by several faults.

At Maungamaungaroa Creek there is another outcrop, and, judging from the dip, these beds should be nearly at the lowest horizon of the Turanga greensands, the Parnell grit occurring a little above the greensands.

As seen in a section, close to Onehunga, on the Manukau Harbour, the tuffs resemble the outcrop at Howick.

With regard to the Wairau tuffs, I am inclined to think that, just as in the case of the Cheltenham breccia, it is a group on the whole synchronous (and probably marking a gradual quiescence of the Waitakerei chain), but derived from different vents along the chain, just as in the former case.

Tamaki Tuff.

At the Tamaki and at Maungamaungaroa Stream there occurs a thin tuff (2 ft. thick), with numerous small lapilli, traversed by veins of large calcite crystals. Its position is 30 ft. below the Orakei greensand, as seen at the Tamaki Gulf, some distance from the west head. I have not seen it elsewhere.

The Ponsonby Tuff.

The Ponsonby tuff is a most interesting bed. In the first place, it is quite a thin bed, and yet has a wider distribution than any bed in the Waitemata series. In the second place, it shows some peculiar results of distortion. It is nowhere more than 2 ft. thick, yet it occurs at the Tamaki, at St. Helier's Bay, at the Manukau, at Ponsonby, at Cheltenham, at Narrow Neck, at Wairau Creek, and at Deep Creek. When unearthed it is a blue soft bed, rather sandy to the touch, speckled with white flakes of kaolinised feldspar. These flakes are thickly crowded together, sometimes as many as 500 in a square inch. Occasionally a small red patch of scoria is seen. The rock weathers to a pale-yellow in which the white feldspars are still visible.

On the whole, the bed grows thicker and coarser in a north-westerly or westerly direction, and I believe it came

from some explosive outburst of a Waitakerei volcano. At the Tamaki it occurs as a thin bed 1 ft. thick not far from the west head. There is a bay and two faults at least between it and the Parnell grit. At St. Helier's Bay it occurs at Watson's Point, the westerly head of the bay, among very much contorted strata. It is not very far from the reef of the Cheltenham breccia. At the Manukau it occurs near the Wairau tuffs. Here it has been drawn out in a most curious fashion. The spot is near an area of distortion. All the lumps are elongated in the direction of the dip of the beds.

At Cheltenham it occurs near the breccia, much crushed. At Wairau Creek it occurs on the bank of the creek in the most distorted part of the cliff, and has been crushed out completely, occurring as a lenticular mass.

In all of these localities it seems to be a little above the breccia.

Across the neck on the North Shore no section can be seen, but the dip continues regular. The tuff would therefore seem to be more above the breccia than is usually the case, and some fault may be present.

In the section at Acheron Point the relative positions of the beds are quite clear, but it is not so certain that there is present an extension of the Cheltenham breccia seven or eight miles away. The question of its position at Acheron Point has already been dealt with in describing the Parnell grit.

8. Conclusion.

I have now described all the volcanic beds of the Waitemata series, and (to recapitulate) have come to the following general conclusions: That in late Oligocene times, in the shallow sea near Auckland, there rose a long line of vents, which were at first very powerful and gave rise to several coarse breccias, laid down amid conflicting currents on the fossiliferous sea-floor. But, as usual, after these first violent eruptions, from which were derived the Cheltenham breccia and the Whangaparaoa breccia, and no doubt several others, besides the massive breccias found on the west coast, there were other manifestations of volcanic activity, on the whole more feeble, but some explosive eruptions on a large scale; and it is to these we must look for the source of the Wairau tuffs and the Ponsonby tuff. Meanwhile the whole area gradually sank, till, towards the close of the Miocene period, the Palæozoic islands and ridges were mostly covered by the waves of the advancing sea, which laid down in regular succession shales and sandstones, even on the older lava-streams of the Waitakerei vents. But at the same time, and probably earlier too, volcanic outbursts were taking place on the Coromandel Peninsula, some of them of sufficient magnitude

to scatter their *débris* over the floor of the Auckland sea; and it is to these we owe the Parnell grit. At a later period the volcanic forces became quiescent, the Miocene strata were raised and extensively denuded, and between the two former lines of volcanic activity arose scores of puys, which covered the older strata with tuffs and basic lavas, and distorted the beds, raising them sometimes, perhaps, from the sea; though I believe the majority of these puy cones arose on the land. One conclusion of interest is that these areas of volcanic disturbance were areas of subsidence, not elevation.*

It is possible that the Waitakerei outbursts were at first submarine, and the opening phase may have been one of elevation. But while the vents discharged their contents the sea-floor gradually sank. It was only when volcanic energy had completely died away that the consolidated sandstones, shales, and tuffs were thrown into long gentle anticlines and synclines, to be denuded by the atmospheric forces, until, after another phase of volcanic history of quite a different type, they again began to sink beneath the waves.

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* See Sir A. Geikie: "Ancient Volcanoes of Great Britain," vol. ii., p. 470.

V.—CHEMISTRY AND PHYSICS.

Art. XLVI.—*Studies on the Chemistry of the New Zealand Flora.*

By T. H. Easterfield, Professor of Chemistry, Victoria College, and B. C. Aston, Chemist to the Agricultural Department.

[*Read before the Wellington Philosophical Society, 5th November, 1901.*]

PART II.—THE KARAKA-NUT.

(Preliminary Note.)

The karaka-tree (*Corynocarpus lævigata*) is endemic to New Zealand and the surrounding islands. It is plentiful in the North Island, but its distribution in the South Island is very limited. It is the largest and commonest of all the trees in the Chatham Islands, where it attains a height of over 50 ft.

The kernel of the karaka-berry is known to be very poisonous in its raw state, but if suitably prepared by cooking and subsequent soaking the kernel forms a staple article of Maori food. A detailed account of the process as carried out by the Maoris is given in a paper by Skey.* Owing to the kindness of Mr. H. B. Kirk, Inspector of Native Schools, we have been informed that the process employed by the Morioris in the Chatham Islands is practically identical with that used by the Maoris.

The karaka-kernels have been investigated by Skey. The results of his examination showed—(1) That the kernels contain oil, sugary matter, gum, and amorphous proteids; (2) that the nuts lose their bitter taste when heated to 100° C. for four hours; (3) that animal charcoal removes from the acidified aqueous extract of the kernel a bitter crystalline substance. This compound was named "karakin," but was not obtained in sufficient quantity for a satisfactory examination.

The authors have re-examined the karaka-nut. They find —(1.) That the aqueous extract of the nut yields much prussic acid on distillation. (2.) That air-dried kernels contain 14–15 per cent. of non-drying oil, which yields solid acids on saponification. (3.) That the sugars present are mannose and dextrose. (4.) That the aqueous extract, upon evaporation, even at 35°, in shallow pans, loses the greater part of its bitter taste. The concentrated extract contains no karakin

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* Trans. N.Z. Inst., vol. iv., p. 318.

(see below), but a nitrogenous glucoside, corynocarpin, together with a highly soluble, non-nitrogenous, crystalline compound. These substances have not been detected in the fresh extract. (5.) That a compound agreeing in nearly all respects with Skey's karakin can be readily obtained from fresh kernels by extracting with cold alcohol, and subsequently distilling off the spirit in a partial vacuum. By repeated crystallization from hot alcohol the karakin is obtained in radiating acicular crystals. (6.) The quantity of karakin diminishes rapidly with the age of the nut. The yield from fresh nuts gathered in February, 1901, was 0·3 per cent.; nuts three months old only yielded 0·1 per cent.; after twelve months the nuts were still bitter, but only a small quantity of karakin was obtained from them.

Karakin.

Since this compound is the only substance in the fresh nut of any considerable interest, the method of preparation and properties of it shall alone be given in detail. The fresh kernels are first put through a sausage-machine, and then through the wooden rollers of a wringing-machine, and the mash well stirred with one and a half times its weight of methylated spirit and allowed to stand for thirty-six hours, with repeated stirrings. The spirit is removed by a filter-press and the press-cake again extracted with alcohol. The united filtrates are distilled in a partial vacuum, at a temperature not exceeding 35°, until the greater part of the alcohol is removed. The turbid liquid gradually deposits crystals of karakin, together with a gummy bitter substance which can be removed by recrystallization from boiling alcohol. The pure karakin melts at 122°, dissolves easily in acetone, methyl alcohol, glacial acetic acid, acetic ether, and phenol; with difficulty in cold ethyl alcohol (0·4 gram in 100 cc.) and water. It is very sparingly soluble in ether and benzene. Deposited from hot concentrated solutions in water or alcohol, it separates as an oil, which subsequently becomes crystalline. The compound reduces Fehling's solution readily. After hydrolysis with dilute hydrochloric acid it gives a yellow precipitate when warmed with sodium-acetate and phenyl-hydrazine solution (glucoside reaction). It is highly nitrogenous. Analysis agrees with the formula $(C_5H_8NO_5)_3$.

		Calculated.	Found.
C	=	37·0	37·2
H	=	4·9	4·8
N	=	8·6	8·6
O (by difference)	=	49·5	49·4
		100·0	100·0

Molecular weight in phenol solution: Calculated $(C_5H_8NO_5)_3 = 486$; found $= 450$.

The characters given by Skey for the karakin prepared by the animal-charcoal method differ in two important respects from those above described. The melting-point according to Skey is 100°, and the substance contains no nitrogen. At first sight it would therefore seem that the two substances are not identical. From Skey's paper, however, it would appear that the karakin was not recrystallized, and this would account for the difference in the melting-points. The failure, on the other hand, to detect nitrogen in organic substances has occurred so often in the history of chemical research, more particularly before the application of the metallic-sodium test had become general, that the authors do not attach much importance to this apparent discrepancy. They would add that they have prepared karakin by Skey's method and found it to contain nitrogen, and to have the same melting-point as the compound already described.

The expenses in connection with this investigation have been defrayed by a grant from the Royal Society of London.

ART. XLVII.—*Raoult's Method for Molecular Weight Determination.*

By Professor EASTERFIELD and JAMES BEE, M.A.

[*Read before the Wellington Philosophical Society, 5th November, 1901.*]

THE teaching of practical chemistry at the present day differs greatly from the teaching in vogue twenty-five years ago. At that time qualitative analysis only was, as a rule, taught to the elementary student, and experimental proof of chemical theory was either ignored or only practised in the lecture-room. Nowadays, however, the teaching of qualitative analysis is usually prefaced by a series of simple quantitative experiments, performed by the students themselves, and designed to illustrate modern chemical principles. Such an introduction greatly facilitates the understanding of the science.

So far as we are aware, no attempt has been made to teach the practice of molecular-weight determination by Raoult's method to the elementary student, it being generally supposed that expensive apparatus is necessary for such determinations. As a matter of fact, the experiment may be successfully carried out with the simplest of school apparatus, and with a very small expenditure of time and material.

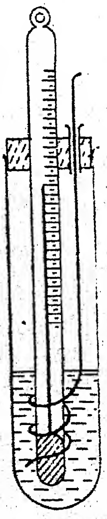
Raoult's law states that the depression in the freezing-point of a given solvent is directly proportional to the concentration of the solution and inversely to the molecular weight of the dissolved substance—*i.e.*,

$$D \propto \frac{}{WM},$$

where D = depression in freezing-point, W = weight of the solvent, w = weight of the dissolved substance, and M = molecular weight of the dissolved substance. So that, if K represent the depression which the molecular weight of *any* substance (in grams) will cause in 100 grams of the solvent,

$$M = \frac{w \times 100}{W \times D} K.$$

This method of determining molecular weights is in every-day practice amongst research chemists, giving good results even for substances with very high molecular weights. With such substances the observed depression is so small that an exceedingly sensitive, and therefore expensive, thermometer is required. For class purposes, however, we must make the depression large enough to be easily registered on a common thermometer. This is easily done by choosing a solvent whose depression constant (K) is large, and dissolving in it some substance whose molecular weight is small.



Now, of all common substances water has the lowest molecular weight, whilst phenol has the highest depression constant (72); indeed, 1 per cent. of water depresses the melting-point of phenol about 4° C.

The apparatus needed is illustrated in the figure. As it consists only of a test tube, common centigrade thermometer, cork, and brass-wire stirrer, no explanation is necessary.

To perform the experiment about 10 grams of good carbolic acid is weighed into the test tube, thoroughly melted by immersing for a few moments in hot water, and the freezing-point determined by thoroughly stirring until the superfused liquid begins to crystallize and the temperature indicated by the thermometer becomes steady. This operation should, of course, be repeated. About 0·1 gram of water is now added to the carbolic acid in the tube, and the freezing-point again determined. The water is conveniently added from a dropping-pipette, the number of drops being carefully counted, and the number of drops which make up a cubic centimeter being determined in a separate experiment.

The numbers obtained by the members of a large class of elementary students varied from 17 to 21 for the molecular weight of water. Still better results were obtained for the molecular weight of methyl alcohol. It is instructive to allow the students to perform a series of experiments at different concentrations. In the case of water in phenol the observed molecular weight increases very rapidly with the concentration (molecular association). Scarcely any such effect is noticed with methyl alcohol in phenol.

ART. XLVIII.—*The Vapour Densities of the Fatty Acids.*

By Professor EASTERFIELD and P. W. ROBERTSON.

[*Read before the Wellington Philosophical Society, 11th February, 1902.*]

It is well known that a large number of substances have vapour densities at their boiling-points which are a little above those calculated from their molecular weights. This may in many cases be explained by the fact that the gaseous laws which are used in the calculations are not rigorously true at the point of liquefaction. In other cases, however, the abnormality is undoubtedly due to the fact that association of the molecules takes place at temperatures in the neighbourhood of the boiling-point.

The first substance to attract the attention of chemists was acetic acid. That the abnormality in this case is really due to the formation of molecular complexes is shown, first, by the fact that the normal vapour density is not reached till 110° above the boiling-point. Secondly, the value for the expression MW/T' (where M is the molecular weight, W the latent heat of vaporization) is 15, while for liquids of normal molecular weight a constant value of about 21 is obtained. This low value can only be explained on the assumption that the molecules are associated in the gaseous state.

Similarly, it was found that normal butyric and isovaleric acids were associated, although to a less extent. In general it may be said that this is true of all the lower fatty acids and their derivatives, which do not decompose on heating. This is quite analogous to their behaviour in solution. In benzene and naphthalene most hydroxyl compounds, and especially acids, associate.* This is also true for the solvents bromoform, nitrobenzene, and parabromtoluene. Even in phenol,

* Auwers, Zeit. Phys. Chêm., 1893, &c.

which owes its wide application in cryoscopy to its slight tendency to cause bodies to associate, the experiments of the authors have shown that, while the alcohols and other aliphatic compounds remain fairly normal, the fatty acids associate strongly with rising concentration. This, however, will be discussed in a future communication.

1. Acetic acid has already been examined in detail. The following are a few of the numbers :—*

Temperature. (Boiling-point, 119° C.).	Density. (Normal Molecular Weight, 2·08).
125°	3·20
130°	3·12
140°	2·90
160°	2·48
190°	2·30
219°	2·17
230°	2·09
250°	2·08

On plotting these results as a curve it is found that the rate of dissociation of these molecular complexes is a direct function of the temperature for 50° above the boiling-point. Then the rate is gradually decreased till 230° C., when the vapour density becomes constant.

2. We can find no record of any determinations made with propionic acid, the next member of the fatty acids. Accordingly we performed several experiments by the ordinary method of Dumas.

(*a*.) At 146° C. and at 760 mm. the vapour density was found to be 51. The normal value is 37; consequently at 5° above the boiling-point the vapour is associated 38 per cent.

(*b*.) At 192° C. and at 755 mm. the vapour density was found to be 45, indicating 22 per cent. association.

3. Normal butyric has already had its vapour density determined at different temperatures.† A normal value is reached at a temperature of about 100° above the boiling-point of the compound. By continuing the curve for butyric acid it is found that the vapour density 5° above its boiling-point would be 3·8—*i.e.*, at that temperature it is associated 25 per cent. Thus for the three acids at 5° above their boiling-points—

	Vapour associated.
Acetic acid	54 per cent.
Propionic acid	38 "
Butyric acid	25 "

* Cahours, "Comptes Rendus," xx., 51.
† Cahours, *loc. cit.*

Thus it is noticed that the amount of association decreases with rising molecular weight, which fact is of universal occurrence for homologous bodies in the liquid state (Ramsay and Shields; Traube) as well as for substances in solution (Biltz).

In this case, however, it happens that the amount of association is inversely as the square of the molecular weight:—

	Per Cent. Amount of Association.	Numbers Proportional to Inverse of Square of Molecular Weight.
Acetic acid ...	54	52
Propionic acid ...	38	36
Butyric acid ...	25	26

Further experiments are in progress with the object of ascertaining whether the same law holds for the higher members of the series.

Art. XLIX.—*The Latent Heats of Fusion of the Elements and Compounds.*

By P. W. Robertson, Junior Scholar in the University of New Zealand.

Communicated by Professor Easterfield.

[*Read before the Wellington Philosophical Society, 11th February, 1902.*]

Abstract.

Crompton states that $\frac{Aw}{Tv} = K$, where A is atomic weight, w latent heat of fusion, T melting point on absolute scale, and v the valency of the element. Now, the valency of an element is known to vary, and as the results were not very concordant the author, from theoretical grounds, replaced this by the relation $\frac{Aw}{T\sqrt[3]{\frac{A}{d}}}$ where d is density and $\sqrt[3]{\frac{A}{d}}$ represents the space between the atoms. Just as the atomic heat of the elements is only constant for elements with atomic weights over about 40, so is this relation only true under the same conditions. In the case of the fourteen elements with atomic weights over 40 the value varies between 1 and 1·3, with the exception of the three, gallium, lead, and bismuth. But applying this rule to the compounds, and changing the atomic weight into molecular weight, still more concordant results are obtained. Out of thirteen inorganic compounds, with the exception of two the results vary from 1·9 to 2·3, being mostly near the mean 2·1. There is also good agreement among the organic bodies examined, the mean being about 2·4. The author intends to calculate more results, and to present fuller tables to the Society.

Various attempts have been made to arrive at a definite

law connecting the latent heats of fusion with the atomic weights and other physical constants. Berthelot (1895), after proving that in the case of the latent heads of vaporization $MW/T' =$ constant (where M is the molecular weight, W the latent heat of vaporization, and T′ the boiling-point on the absolute scale), supposed a similar law to be true in the case of the latent heats of fusion.

Holland Crompton, in a paper entitled "Latent Heat of Fusion,"* endeavoured to show that the equation $Aw/Tv =$ a constant for the elements, A being the atomic weight, w the latent heat of fusion, and v the valency. The difficulty first encountered in this relation is due to the fact that the valency of an element varies with its mode of combination and with different physical conditions.

Shortly afterwards Deerr† concluded that the relationship Aw/T is constant only for certain groups of "similar" elements.

In 1897 Crompton published another paper,‡ in which he attempted to disprove the hypothesis of electrolytic dissociation. He arrives at the result $dw/T =$ constant for monomolecular liquids, where d is the density of the liquid. In the same paper the results are given for the elements, the densities in many cases being taken in the solid state. As shown below, the numbers are exceedingly divergent.

De Forcrand§ showed that $M(W+w)/T'$ is approximately constant: M is the molecular weight of the substance in the state of a gas at its boiling-point T′, and W and w are the latent heats of vaporization and fusion respectively. But W is generally about ten times as great as w; and, as $MW/T' =$ a constant is true (Trouton's law), the value of w will make little difference in the result. Further, if the equation $M(W+w)/T'$ be divided by the constant MW/T', it follows that $W/w =$ a constant. Using Traube's numbers for the latent heats of vaporization of the following elements, which gave very satisfactory numbers for Trouton's constant, the values of W/w are—Mercury, 26; zinc, 14; cadmium, 15; bromine, 3; iodine, 3·2; bismuth, 17. Since these numbers should be equal if De Forcrand's relationship is a physical law, his generalisation may be dismissed without further consideration.

Now, let it be assumed for the present that $Aw/T = 8{\cdot}8$ (this value is only empirical, but its magnitude will not affect the following argument). On dividing the values of A thus obtained by the real atomic weights, the result is a series

* Journ. Chem. Soc., 1895, 67. 315.
† Proc. Chem. Soc., 1895, and Chem. News, 1897.
‡ Journ. Chem. Soc., 70, 925.
§ "Comptes Rendus," 1901, 132, 878.

of numbers which appear to be periodic functions of the atomic weights:—

TABLE I.

Cu.	Zn.	Ga.	Ge.	As.	Se.	Br.
3·8	3·1	1·7	..	..	..	2·4
Ag.	Cd.	In.	Sn.	Sb.	Te.	I.
3·7	3·4	..	2·6	..	..	2·3
Au.	Hg.	Tl.	Pb.	Bi.		
3·8	3·6	3·6	4·4	1·9		

It will be noticed that the values tend to increase from top to bottom and from right to left—*e.g.*, zinc to mercury and iodine to silver. It would seem, therefore, that some periodic quantity must take the place of the v in Crompton's formula to make the relation true for all the elements.

It can be proved that TS/w = a constant, where S is the specific heat of the element, by using the relation TC = a constant, C being the coefficient of expansion. But Pictet proves $TC\sqrt[3]{\frac{A}{d}} = K$, the expression $\sqrt[3]{\frac{A}{d}}$ representing the mean distance between the atoms if d is the density. Applying this, it follows that—

$$\frac{TS\sqrt[3]{\frac{A}{d}}}{w} = \text{constant.}$$

$$\text{But} \quad AS = \text{constant (Dulong and Petit);}$$

$$\therefore \quad \frac{Aw}{T\sqrt[3]{\frac{A}{d}}} = \text{constant.}$$

In Table II. are given the values thus calculated for the elements with atomic weights above 40 whose latent heats are known. As in the case of Dulong and Petit's law, the relationship does not hold for the elements with low atomic weights. The values of d are taken at ordinary temperatures for the substances in the solid state, except in the case of bromine, the specific gravity of which in the solid state is unknown. Most of the constants required have been obtained from the papers of Crompton and Deerr, while the values for silver and copper are due to Heycock and Neville.*

* Trans. Royal Soc., 1897, 189, 25.

TABLE II.—ELEMENTS.

Element.	Aw.	T.	$\sqrt[3]{\frac{A}{d}}$	$\frac{Aw}{T\sqrt[3]{\frac{A}{d}}}$
Mercury	565	234	2·41	1·00
Zinc	1839	688	2·12	1·28
Cadmium	1531	593	2·35	1·10
Bismuth	2602	540	2·77	1·75
Gallium	1336	286	2·28	2·05
Palladium	3873	1773	2·09	1·05
Gold	3227	1335	2·15	1·12
Tin	1573	503	2·55	1·22
Lead	1212	600	2·61	0·76
Thallium*	1183	562	2·62	0·82
Bromine	1295	266	2·97 (?)	1·63 (?)
Iodine	1485	387	2·96	1·28
Copper	3140	1355	1·91	1·22
Silver	2920	1230	2·16	1·10
Platinum	5295	2052	2·10	1·23

The greatest discrepancies are observed in the cases of bismuth and gallium, the only two metals which are known to expand on freezing.

By using the results of Heycock and Neville for the freezing-points of alloys the value for lead becomes about 1. Their experiments confirm the values of zinc, cadmium, tin, and bismuth, the first three of which give concordant results for the constant. Using this value for lead, and excluding bismuth and gallium, the results vary from 1 to 1·3 for twelve elements with melting-points ranging from $-40°$ to $+1,800°$ C. The mean value is 1·16. In the table below the results are compared with those of Crompton:—

TABLE III.

Element.	A.	B.	C.	D.	E.
Mercury	1·00	−14	1·21	− 8	1·65
Zinc	1·28	+10	1·34	+ 3	2·65
Cadmium	1·10	− 5	1·29	− 1	1·84
Palladium	1·05	−10	1·09	−16	2·83
Platinum	1·23	+ 4	1·29	− 1	2·33
Tin	1·22	+ 5	1·56	+21	1·86
Silver	1·10	− 5	2·37	+80	2·08
Gold	1·13	− 3	0·80	−40	2·36
Copper	1·22	+ 5	1·16	−10	3·26
Iodine	1·28	+10	1·27	− 2	1·48
Lead	1·00	−14	0·97	−25	1·00
Thallium	1·02	−12	2·62	+100	1·52

* Since the paper was communicated to the Society the latent heat of fusion of thallium has been directly determined by the author. The value thus found (mean of ten observations) gives a value of 1·02 for the final expression. Thallium thus conforms to the general law.

A represents $Aw/T\sqrt[3]{\frac{A}{d}}$.
B represents percentage difference from mean.
C represents Crompton's 1895 relation, Aw/Tv.
D represents percentage difference from mean.
E represents Crompton's 1897 relation, $10 \times wd/T$.

Thus the relationship $Aw/T\sqrt[3]{\frac{A}{d}}$ is much the most satisfactory, the mean deviation being ± 8 per cent., a deviation of the same order as observed in the law of Dulong and Petit. But it must be borne in mind that the latent heat of fusion is one of the most difficult physical constants to determine, and that if the densities were taken at some corresponding temperatures, such as at the melting-points, the results would perhaps be even closer. There is a large number of wide deviations in Crompton's first relation, while in the case of bromine and iodine it was assumed that the valencies were 3, which assumption is decidedly open to criticism.

In the case of compounds, if A is replaced by M (molecular weight) the values for $Mw/T\sqrt[3]{\frac{M}{d}}$ are also found to be constant. The following are the data for those substances whose density in the solid state I have been able to find. The values for lead-bromide and silver-chloride are from the results of Weber, who deduced them from electrical experiments. The latent heats of antimony chloride and bromide and the bromides of tin and arsenic have been calculated from their depression constants. The remaining numbers are taken from Crompton's paper.

TABLE IV.

A. INORGANIC COMPOUNDS.

Compound.	Mw.	T.	$\sqrt[3]{\frac{M}{d}}$	$\frac{Mw}{T\sqrt[3]{\frac{M}{d}}}$	$\frac{10 \times dw}{T}$
Lead-chloride	5810	758	3·64	2·10	1·60
Lead-bromide	5100	763	3·80	1·76	1·23
Lead-iodide	5300	648	4·17	1·98	1·10
Silver chloride	4400	730	3·07	1·96	2·35
Antimony-chloride ..	2920	345	4·19	2·01	1·24
Tin-bromide	2910	303	5·11	1·90	0·73
Antimony-bromide ..	3490	369	4·42	2·15	1·10
Arsenic-bromide ..	2740	295	4·39	2·11	1·14
Water	1439	273	2·70	1·96	2·93
Iodine-chloride	2297	289	3·70	2·14	1·52
Potassium-nitrate ..	4949	606	3·65	2·24	1·69
Sodium-nitrate	5520	578	3·40	2·81	2·46

With the exception of lead-bromide and sodium-nitrate, the numbers vary from 1·9 to 2·2, with the value 2·07 as mean.

B. Organic Compounds.

Compound.	Mw.	T.	$\sqrt[3]{\frac{M}{d}}$	$\frac{Mw}{T\sqrt[3]{\frac{M}{d}}}$	$\frac{10 \times dw}{T}$
Acetic acid	2661	277	3·84	2·50	1·61
Phenylacetic acid ..	4293	348	4·80	2·56	1·00
Azobenzene	5187	342	5·31	2·85	0·87
Benzoic acid	4607	396	4·56	2·55	1·08
Orthonitrophenol ..	3725	316	4·60	2·56	1·10
P. dichlorobenzene ..	4395	325	4·90	2·76	1·15
P. dibromobenzene ..	4862	358	5·04	2·70	1·06
Diphenyl	4391	343	5·36	2·39	0·83
Naphthalene	4559	353	4·81	2·67	0·99
Resorcinol	4906	383	4·41	2·90	1·37
Paratoluidine	4177	312	4·67	2·87	1·21
Parabromphenol ..	3961	337	4·62	2·55	1·09
Parachloraniline ..	4742	342	4·73	2·74	1·30
Phenanthrene	4450	369	5·50	2·19	0·71
Thymol	4130	321	5·36	2·41	0·81
Nitronaphthalene ..	4383	329	5·06	2·64	0·97
Anethoil	4070	294	5·30	2·61	0·94
Nitrobenzene	2743	264	4·45	2·35	1·02
Acetophenone	3540	293	4·86	2·53	1·02
Benzophenone* ..	4320	321	5·38	2·50	0·90
Chloracetic acid* ..	3850	334	4·04	2·90	1·71
Acetoxime*	3022	333	4·22	2·15	1·12

With the exceptions of acetoxime and phenanthrene, the numbers vary from 2·35 to 2·9. The mean value 2·57 is distinctly greater than the value obtained for the inorganic compounds. Whether this difference is due to the large number of atoms in the compounds of carbon or whether it is one of those peculiar properties of this element remains to be seen. The value of the constant is about twice as great as that obtained for the elements themselves.

I have neglected to compare Crompton's 1895 relation $Mw/T\Sigma V$ with the others, because until chemists can agree as to what is really meant by the sum of the valencies (ΣV) in a compound the results thus obtained will be of no value. In the last column of Table IV. is placed his second relationship, $10 \times wd/T$. Regarding this, he says that when the result is about unity the liquids are non-associated, and when greater the liquid is proportionately associated. It may be remarked that about 25 per cent. of the values are considerably "below" unity.

* Specific gravity in the solid state determined by the author.

By combining the equation $Mw/T\sqrt[3]{\frac{M}{d}}$ with the well-known law of Van t'Hoff, $D = \cdot 02T^2/w$, the result is $D = KMT\sqrt[3]{\frac{M}{d}}$, where D is the molecular depression of the solvent and K a constant. Hence the molecular depression of any body can now be calculated without a knowledge of the latent heat of fusion.

Trouton's law states that—

$$MW/T^1 = K^1.$$

$$\text{But} \quad Mw/T\sqrt[3]{\frac{M}{d}} = K;$$

$$\therefore \quad w/W = c\,T\sqrt[3]{\frac{M}{d}}/T^1.$$

That is, the latent heat of fusion is to the latent heat of vaporization as the freezing-point multiplied by the cube root of the specific volume is to the boiling-point. This, of course, is only true when Trouton's law is true—that is, when the molecular condition of the body is unchanged in passing from the liquid to the gaseous state.

ART. L.—*Some Observations on the Fourth Dimension.*

By the Rev. HERBERT W. WILLIAMS, M.A.

[*Read before the Hawke's Bay Philosophical Institute, 9th September, 1901.*]

HELMHOLTZ was the earliest writer to attempt to present the conception of transcendental space in a form inviting popular investigation, and his efforts have been ably seconded in recent times by the author of "Flatland,"* in the first place, and by Mr. C. H. Hinton,† in the second place. The former has produced a work which has attractions beyond the mere consideration of the fairyland of mathematics; while the latter, beginning with pamphlets of a distinctly popular nature, has in his latest work laid down, still without abstruse mathematics, a scheme of mental training the avowed object of which is to enable the student to form a perfect mental image of a figure in four dimensions.

* "Flatland, A Romance in Two Dimensions, by a Square." Seeley and Co.

† Author of "Scientific Romances" and "A New Era of Thought." Swann, Sonnenschein, and Co.

The method of treatment does not admit of much originality. A straight line bounded by two points will, if moved in a direction perpendicular to itself, trace out a square, bounded by four lines and four points. By moving this square in an independent direction at right angles to the two original directions we shall obtain a cube, bounded by six squares, twelve lines, and eight points. If the cube be now moved in an independent direction compounded of none of the three original directions, but at right angles to them all, it will trace out a four-dimensional figure (called by Mr. Hinton a "tessaract") which will be bounded by eight cubes, twenty-four squares, thirty-two lines, and sixteen points.

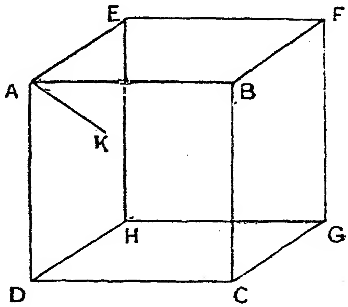
A very small amount of consideration will show how these latter figures are arrived at. The bounding cubes consist of the cube in its original position, the cube in its final position, and the six cubes traced out by the motion of the six squares which bounded the cube. Of the squares we had six in the initial and six in the final position, while each of the twelve lines of the cube traced a square, making twenty-four in all. So too with the lines: twelve in the initial and twelve in the final position, with eight traced by the eight points, bring up the total to thirty-two. We may tabulate these results as follows:—

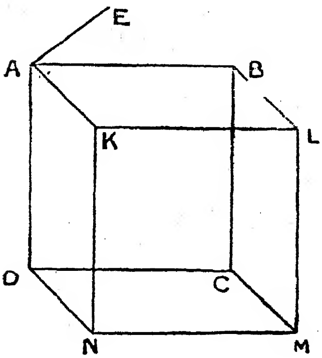
	Dimensions.	Points.	Lines.	Squares.	Cubes.
Line...	1	2	...	...	...
Square	2	4	4	...	...
Cube	3	8	12	6	...
Tessaract	4	16	32	24	8

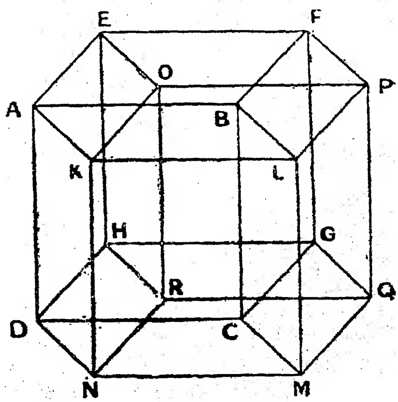
We might, of course, carry on the enumeration for figures in five, six, or "*n*" dimensions.

Mr. Hinton remarks that, if we take two equal cubes and place them with their sides parallel and connect the corresponding corners by lines, we shall form the figure of a tessaract. But it seems to the present writer that this suggestion ignores the limitation of our three-dimensional space. It is just these limitations which prevent our placing the cubes in a satisfactory position. The suggestion contains the assumption that, as we may project a cube on to a plane, so we may project a tessaract on to a three-dimensional system. In point of fact, such a projection might be made by a being in four dimensions, but we three-dimensional beings must be content with projecting our tessaract upon a plane.

Use has accustomed us to the fact that we may represent by projection the figure traced by the square ABCD when moved in a direction (parallel to AE) perpendicular to all the lines contained in itself. And in a projection there is nothing to hinder us from moving the cube AG, thus obtained, in a direction represented by AK, which shall be at right angles to AE, AB, and AD. In fact, we might, had we been so disposed, have moved our square AC in that direction, and traced, instead of AG, the cube AM, without doing any violence to our notions of the propriety of our dealings with the projection. By moving, then, either the cube AG in a direction AK perpendicular to each of its sides, or the cube AM in a direction AE perpendicular to each of its sides, we shall obtain a projection of the tessaract AQ which will be found to have all the defining elements which are contained in the table above. There are the eight cubes, AM, EQ, AR, BQ, KF, NG, AG, KQ: the twenty-four squares, AC, EG, KM, OQ; AL, EP, DM, HQ; AN, ER, BM, FQ; AH, KR, BG, LQ; AO, BP, DR, CQ; AF, KP, DG, NQ: the thirty-two lines, AE, KO, DH, NR, BF, LP, CG, MQ, AB, KL, EF, OP, HG, RQ, DC, NM, AK, EO, DN, HR, BL, FP, CM, GQ, AD, KN, EH, OR, BC, LM, FG, PQ: and the sixteen points, A, B, C, D, E, F, G, H, K, L, M, N, O, P, Q, R.



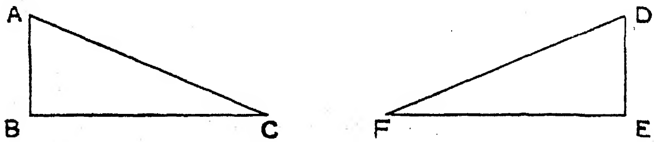




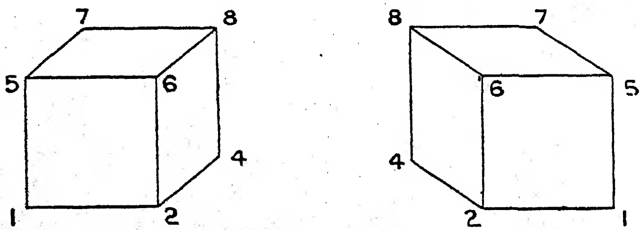
As has been indicated above, any one of the eight cubes here enume-

rated might have been considered the generating-cube, which in turn gives us the option of starting from any one of the twenty-four squares or the thirty-two lines.

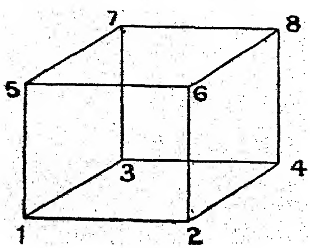
In two dimensions revolution takes place about a point, while figures are bounded by lines. In three-dimensional space revolution takes place about a line, and figures are bounded by surfaces. In four dimensions revolution takes place about a plane, and figures are bounded by solids.



To a two-dimensional being the figures ABC, DEF are essentially different, no amount of revolution about a point effecting coincidence. To us, however, it is obvious that one can be made to coincide with the other by performing half a revolution about a line. Similarly, to us the cubes figured below are essentially different, and no revolution



about a line can make them coincide. To effect this one must be taken into four-dimensional space and revolved about a plane. Another aspect of the same fact is that, as we appreciate the identity of the two triangles by concentrating our attention upon one face or the other of either triangle, so a four-dimensional being appreciates the identity of the two cubes by virtue of the fact that either side is equally accessible to him. As the faces of the cube are no greater hindrance to him than are the edges of a triangle or square to us, he can apprehend the cube with the angle (6) forward or with the angle (3) forward at will; the latter being the cube B, the former being the cube A, above.



The realisation of the possibility of the existence of fourth-dimensional space leads naturally to two questions, which, of course, may suggest others: (1.) Seeing that we may conceive of our space system as being made up of innumerable two-dimensional systems, each possibly inhabited by beings quite without cognisance of the companion systems, may not four-dimensional space be compounded of innumerable three-dimensional systems, similar to our own, but lying completely outside our cognisance? (2.) Seeing that figures in a two-dimensional system might be regarded as sections of solids, might not our so-called solids be in reality sections in three dimensions of four-dimensional figures?

With regard to the first question, it does not appear that any reason can be adduced why it should not be answered in the affirmative. This leads to the curious consideration that, in spite of preconceived notions, two bodies may, apparently, occupy the same space. If one plane be superimposed upon another, a figure moved out of the latter an infinitely small distance passes into the other. Two beings might in this way be separated by the smallest possible distance, and yet for all practical purposes be at an infinite distance from one another. In the same way, if we conceive of a cube, say of 1 ft. side, moved one millionth part of an inch in the direction of the fourth axis, it will pass immediately out of our system, and presumably its place may be occupied by another cube similar to itself. The centres of gravity of the two would be separated by an infinitesimal distance, and yet each in its own space system might be a solid, the two cubes to all intents and purposes occupying the same space. In this connection it may be mentioned that it has been suggested that, as we may imagine a plane to be bent over so as to re-enter itself, with or without a twist in the process, so we may suppose it possible for our space system to have been similarly treated. This would make it possible to arrive at one's starting-point by travelling along an apparently straight line for a considerable distance. But though the notion of limited space thus introduced had attractions for so great a thinker as W. K. Clifford, it seems that such a process would involve an extension of our present three-dimensional limitations.

With regard to the second question, while solids may mathematically be such sections, the answer must, when we come to the case of animate beings, assuredly be a negative one, for it is scarcely conceivable that a section could contain the consciousness of the whole. If what we imagine to be independent figures proper to our own space system are but sections of four-dimensional figures, it would seem to be necessary that the innumerable sections of these solids are also playing their parts in an infinite number of two-dimen-

sional space systems. The author of "Flatland" makes a sphere pass in and out of two-dimensional space, and thereby conveys the suggestion that higher space beings might similarly visit our space and similarly disappear. In fact, the idea has been seized upon as explaining many of the so-called phenomena of Spiritism. But writers on this point have not reckoned with the difficulty of insuring that the higher space being should always offer the same three-dimensional section on entering our space system. Even so simple a figure as a cube might appear in a two-dimensional universe as a point, a line, a triangle, quadrilateral, or five-, or six-sided figures. In fact, under each of the four last headings an infinite variety of forms might be offered. And the possible sections of a four-dimensional figure in space of three axes offers, of course, a far greater variety of forms. It is not conceivable that a being moving freely in space of four dimensions could present itself repeatedly to us in sections even suggesting identity of form.

There is one further objection which must be dealt with in reference to both the above questions. The assumption is usually made by writers on this subject, and has been tacitly accepted in this paper, that a figure might be removed from a plane and afterwards replaced in that plane; and, by analogy, that one of our solids might conceivably be lifted into four-dimensional space and afterwards replaced in our system. Now, either of these processes endues the body dealt with for the time being with an existence in a system higher by one dimension than that in which it was assumed to exist. Two-dimensional beings, if such there be, are by the nature of their limitations placed absolutely without the scope of our cognisance, and we, of course, without the scope of theirs. So too we, as long as we continue to be three-dimensional beings, are absolutely cut off from such four-dimensional beings as there may be. The method of treatment adopted by writers in endeavouring to place the conception of the fourth dimension within reach of their readers consists in developing figures from one space system to another. But it is a fallacy to suppose that the matter occupying a figure can be similarly dealt with. In fact, we have no knowledge or conception of fourth-dimensional *matter*, any more than of two-dimensional *matter*. It is this fallacy which vitiates the application of the fourth dimension to reported spiritist wonders, and the recognition of it restores confidence in the old theory that two bodies cannot occupy the same space. J. B. Stallo remarks* that "the analytical argument in favour of the existence or possibility of transcendental

* "The Concepts and Theories of Modern Physics," p. 269

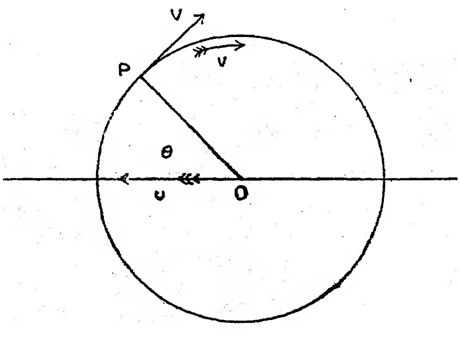
space is another flagrant instance of the reification of concepts." It would appear, however, that his strictures apply not to the arguments for the possibility of transcendental space, but to the arguments that we can have, under our present limitations, any practical acquaintance with such space.

ART. LI.—*The Equatorial Component of the Earth's Motion in Space.*

By DOUGLAS HECTOR.

[*Read before the Wellington Philosophical Society, 11th February, 1902.*]

ATTEMPTS have been made from time to time to find the velocity of the earth—or, rather, the solar system—in space by observing the proper motions of stars. Methods have also been suggested that depend on the relative motions of the earth and ether. The following method, however, I have not seen described anywhere, although it seems extremely simple. If a rotating body moves along a path in the plane of its equator, it is evident that a point on its surface moves faster relatively to space on one side of its path than on the other; but an acceleration is proportional to the rate of change of velocity, so that the point should undergo an alternating acceleration.



Let V = tangential velocity of the point P in space, u = velocity of earth's centre in space, and v = rotational velocity of P. Then, resolving along the tangent, we get $V = v - u \sin. \theta$. If f is the acceleration of P along the tangent,

$$f = \frac{dV}{dt} = -u\frac{d\theta}{dt}\cos. \theta = -u\omega\cos. \theta.$$

The motion of the sun, as deduced from the proper motion of the stars, is, according to Proctor ("The Sun"), 150,000,000 miles per year—that is, 25,154·38 ft. per second, the line of motion being inclined to the earth's orbit at about 53° in longitude 285°. This is about 60° to the earth's axis. Resolving along the equatorial plane, this gives—

$$u = 21{,}784 \text{ ft. per second;}$$

and, as $\omega = 0{\cdot}000073$ rad. per second,

we get $f = -1{\cdot}584 = -\frac{g}{20}$ (about) when $\theta = 0$.

Similarly, this would be the acceleration along the radius at $\theta = 90°$; so that the weight of a body at the equator should vary by 10 per cent. every twelve hours. The motion of the earth in space, therefore, cannot be as great as deduced from the proper motions of stars.

If A be the angle through which a plumb-bob is deflected by this spacial acceleration, we have—

$$\tan. A = \frac{-u\omega \cos. \theta}{u\omega \sin. \theta \cos. \lambda + g}.$$

Perhaps this in some part reconciles the seismological tides found by Milne with Lord Kelvin's value of the rigidity of the earth.

From an experimental point of view the method is very accommodating. Being a harmonic quantity, it does not matter when we set our instruments, which may, for the same reason, measure variations in pressures. Being an acceleration, it may be magnified to any extent by using large masses. With sufficiently delicate apparatus, and observations extending over a long period, it might be possible to deduce the relative motion and distance of a star for which the earth's orbit failed to show any parallax.

Art. LII.—*Mathematical Treatment of the Problem of Production, Rent, Interest, and Wages.*

By Douglas Hector.

[*Read before the Wellington Philosophical Society, 11th February, 1902.*]

The following attempt at a mathematical treatment of some of the problems of political economy was not originally intended for publication, but I have been persuaded to submit it as a paper to the Wellington Philosophical Society. I have not solved all the interesting points in the subject, but merely

a few of the more simple ones. Several attempts have been made to treat political economy mathematically, but they have chiefly resulted in failure, for the reason that the mathematics has taken quite a subordinate part, being used to express the result of elaborate reasoning by words. It is like the man who keeps a watchdog and does the barking himself.

The most successful attempt so far seems to have been made by Professor Jevons,* but he states in his preface that, although many of the problems might have been solved more directly, he preferred to limit himself to the simplest possible mathematics, thus the book hides rather than shows the value of applying mathematics to the subject. Another writer on the subject is Professor J. D. Everett.† A long list of other writers is given at the end of Professor Jevons's book, but the two mentioned are the only mathematical ones to which I have been able to refer; and, from a remark on the customary method of treatment in Professor Everett's paper, I believe that the proofs in the following paper are new, though the results have in many cases been previously obtained by a patient application of logic.

The fundamental principle which is assumed in the following is that in the serious affairs of life a person always endeavours to obtain the maximum return on an investment. This one might almost call an axiom, and as such it is used. With regard to the definitions, I have defined the quantities as I intend to use them, and as long as a definition and its use are consistent no more is required of it.

Many people think that the application of mathematics to political economy is an almost impossible proceeding. The science, they say, is too vague and conditional for it to be possible. The same might have been said of other sciences in their beginnings, but which have since had mathematics successfully applied to them. For instance, what is more capricious than evolution? yet Professor Pearson is successfully applying mathematics to this subject. The problems of political economy in many cases resemble problems in dynamics, and it is quite a possibility that its elements might be expressed in terms of energy which would thus bring it more into line with other branches of applied mathematics. In fact, so apparent are the advantages of the mathematical treatment of the subject to many that a well-known professor jokingly said, in a lecture on the representation of facts by curves, that before long we should probably see our legislators,

* "Theory of Political Economy."

† "On Geometrical Illustrations of the Theory of Rent" (Jour. R.S.S., lxii., 703).

instead of preparing lengthy speeches, framing the laws of the country by means of squared paper and curves.

Some may demur to the latter part of the definition of interest as requiring proof, but it is rather a historical point than otherwise, and, in any case, does not affect results obtained.

DEFINITIONS.

1. "Production" is the changing of form, constitution, place, or time of a natural product of nature in order to render it efficient for human needs.

2. "Land" is the whole of the material universe that has not undergone production.

3. "Labour" is human force applied to production.

4. "Production" (P), when used in a quantitative sense, refers to the value (referred to some convenient standard) of the products after they have undergone the process of production.

5. "Rent" (R) is that portion of production which is given up to landowners in return for benefits derived from land in their possession.

6. "Marginal production" (p) is the production which would be obtained if all the land were equal in productivity to the most productive land available without the payment of rent.

7. "Wages" (W) is that portion of production returned to labour in return for its co-operation in production.

8. "Capital" (C) is the surplus of production which is used to assist labour in further production, by means of costly appliances, &c.

9. "Interest" (I) is that portion of production which is delivered to capital as equal in value to the mean increase of raw products due to the vitality of nature.

10. "Rate of interest" is the fraction obtained by dividing interest by capital.

11. "Proportional profit" is the profit derived from a certain investment divided by the amount invested.

I.

If u be the proportional profit at one point and u' that at another where u is less than u', then motion will take place from u to u', because every one tries to make the greatest profit he can. Further, the greater the difference between u and u' the greater the velocity of adjustment. Therefore, if there be n proportional profits at n different points, there will be a tendency to motion which will cease when all the profits are equal. Therefore, if V, V′, V″, V‴, V⁗, &c., be the amounts invested at different points, the condition that there should be equilibrium is that—

$$\frac{1}{V} \cdot \frac{dV}{dt} = \frac{1}{V'} \cdot \frac{dV'}{dt} = \frac{1}{V''} \cdot \frac{dV''}{dt} = \&c.$$

From this we may deduce a relation between property-values and rate of interest (r).

Let V = property-value.

$$r = \frac{1}{C} \cdot \frac{dC}{dt}$$

$$\text{but} \quad \frac{1}{V} \cdot \frac{dV}{dt} = \frac{1}{C} \cdot \frac{dC}{dt} = r.$$

Integrating, we get—

$$V = V_0 e^{rt},$$
$$\text{and} \quad C = C_0 e^{rt}.$$

This assumes that r is constant, and that all the rent is devoted to buying more land and the interest to increasing capital. Neither of these assumptions is true, for evidently a man who is both a landowner and a capitalist may be most erratic in his investments; but it seems evident that, since the area of land in use is limited, more rent will find its way to capital than interest to land, so that capital will increase more quickly than given above and land-values more slowly. We may, however, deduce a formula free from both these objections by replacing dV/dt by R; then V, R, and r are simultaneous values at any time, and therefore true for all time.

$$\frac{R}{V} = r.$$

Since R is always greater than 0, we see that when $r = 0$ $V = \infty$, and *vice versâ*. There is one case in which $R = 0$: that is at and below the margin of cultivation; the formula then gives $V = 0$. True, but of no importance.

II.

Rent is equal to production *minus* the marginal production.

Let productiveness mean the production from unit-area of ground, and let it be represented by y, and the marginal productiveness by g. Further, let $dR/dx = z$. Then we may write $y = g + z + f(x)$, so that the profit after the rent has been paid is $g + f(x)$; but at the margin no rent has to be paid, so that the profit there is g. Now, if equal areas of land be taken at the margin and at any other point, we have—

$$\frac{1}{C} \cdot \frac{dC}{dt} = \frac{1}{C'} \cdot \frac{dC'}{at}$$

—here I use C and C′ to include not only capital, but also labour—

$$\therefore \quad \frac{g + f(x)}{C} = \frac{g}{C'};$$

$$\text{or} \quad (C - C')g = f(x)C'.$$

If the distribution of C be uniform, $f(x) = 0$, so that—

$$y = g + z.$$

Integrating between suitable limits,—

$$P = p + R,$$
$$\text{or} \quad R = P - p.$$

This is the ordinary theory of rent, which seems always to be deduced by placing the distribution of capital under a restriction; but this is more apparent than real, for C and C′ contain both capital and labour, and to put them equal only means that their joint effects are the same at all points, though the distribution of capital may be extremely variable. This agrees with observation. The less capital a man has to work his land the harder he has to work to keep afloat.

III.—Wages.

$$P = R + I + W,$$
$$= R + p,$$
$$\therefore \quad W = p - I = p - Cr.$$

This shows that if the capital increases whilst p remains constant the wages will fall, and that in new countries, where p is large and C small, the wages should be large.

We have seen in I. that when r is constant $C = C_0 e^{rt}$. Now, suppose I to have reached a constant value, then $C = C_0 + It$. The corresponding land-value will be—

$$V = V_0 e^{\frac{It}{c}}.$$

The Malthusian theory states that population is kept down by its pressure against production—that is, if n is the population and w the demand of each.

$$P = nw,$$
$$\therefore \quad I = p - P = -R,$$
$$\text{since} \quad nw = W.$$

Similarly, if the law were $p = nd$ we should get $I = 0$, which is equally untrue and absurd.

Let the coefficient of labour-saving devices (s) be measured by the production which can be done by unit labour when using a labour-saving device. Then $P = sN$, where N is the number of men required to do this production with this coefficient. If we put $R + I = mP$, where m is some proper fraction, we have—

$$P = mP + W = mP + nw;$$
$$\text{or} \quad P = \frac{nw}{1-m},$$

where n is the number of men available; so that—

$$w = \frac{N}{n}(1-m)s = \frac{P}{n}(1-m).$$

Since $R = P - p$, the effect of increasing P is to increase R without increasing the wages, as the latter are included in p. Therefore to increase w we must increase $(1-m)$—that is, decrease m. Or we may put it that since P is directly proportional to s we must increase the ratio of N/n, which may be done by either increasing N or decreasing n. Let us examine these ways more in detail.

The diminishing of n has in the past been the most common way of increasing wages, but it has been far from successful, having been brought about by wars, pestilences, &c., which tend to diminish P at the same time; also, the destruction of property and ruin of the country generally is so great that the increase of wages is negligible.

The increasing of N has been tried—relief-works, for example—but is expensive, wasteful, and not lasting, for as soon as the artificial stimulant is removed the wages must revert to their former state.

The decreasing of m is what the single-taxers aim at doing, and what the rating on unimproved values aims at effecting. We have seen in II. that rent is the natural outcome of variable productivity and cannot be done away with, but it might be collected by the Government and distributed in the form of efficacious and lasting public works.

ART. LIII.—*On the Phenomena of Variation and their Symbolic Expression.*

By E. G. BROWN.

[*Read before the Wellington Philosophical Society, 11th March, 1902.*]

Plates XXXVI., XXXVII.

"A PERSON who uses an imperfect theory with the confidence due only to a perfect one will naturally fall into abundance of mistakes; his predictions will be crossed by disturbing circumstances of which his theory is not able to take account, and his credit will be lowered by the failure. And inasmuch as more theories are imperfect than are perfect, and of those who attend to anything the number who acquire very sound habits of judging is small compared with that of those who do not get so far, it must have happened, as it has happened, that a great quantity of mistake has been made by those who do not understand the true use of an imperfect theory. Hence much discredit has been brought upon theory in general, and the schism of theoretical and practical men has arisen."—(DE MORGAN, "Penny Cyclopædia," Art. "Theory.")

INTRODUCTION.

The present writer proceeds upon the assumption that the means of comparing those theories which are used to predict

the quantities of physical phenomena with experiment upon those phenomena are in some cases not quite so effective as the theory of probability enables them to be made, and that the latter theory has even had a detrimental effect upon the comparison by reason of it having been frequently assumed to have provided a universally satisfactory method—that of least squares—by which we can determine those constants which arise from the unestablished properties of matter, and at the same time more or less tacitly institute a comparison between the theory and the results of experiment in the case of a phenomenon of variation where quantity is both measurable and supposed determinable by theory, given the properties of matter. The results of the theory of probability will be accepted with regard to the probable value of a single quantity directly measured and its probable error.

In the present paper the writer proposes to examine the representation of physical phenomena of variation by means of formulæ, whether empirical or founded more or less completely upon reason.

1. The phenomena which will be examined are those where a quantity (Y) varies with a variable (X)—that is to say, takes up magnitudes which, *ceteris paribus*, depend in some fixed way upon the magnitude of X. If we observe, by experiment, how the variation occurs we obtain knowledge which can be expressed by a graph. We may make the axis of Y the ordinate, that of X the abscissa. We shall consider only such cases where Y has, in fact, although it may not have been observed, one value, and only one, for each value of X, which in general extends from *plus* to *minus* infinity.*

2. The first fact we notice is that in such case we observe values within a limited range. This we may call the "experimental range of X." Beyond that range we know nothing, whereas most mathematical expressions will yield values from *minus* to *plus* infinity. The definite integral is in form a striking exception to this, and from one's experience of text-book formulæ it is to be wished that some simple means of indicating experimental range could be brought into general use. This idea of dealing with the experimental range only will be found of fundamental importance in later parts of this paper.

3. Now, the graph may be of two distinct kinds—(A) that of a curve or curves, or (B) that of a series of datum points. The first kind, that of a curve, contains the same complete statement of values of Y as does the analogous kind of mathematical formula, which is defined as holding between limits of range of X. The second kind, that of datum points, contains

* But see Appendix, III.

information which may be given also by a table.* This refers to the information which is directly derived from experiment; but, this usually being insufficient for the practical applications, we have to perform interpolation in order to get what we want. This may be done graphically or by application of the calculus, but in either case the result is a guess. It will be here asserted that, *à priori*, we have nothing to show that the judgment of an engineer or physicist will lead to error more readily than will the corresponding assumptions of a computer. We shall refer to the judgment as the arbiter in this indeterminate question of interpolation.

4. So far we have accepted the results of experiment, but it is evident that such knowledge must (in continuous variation) be inaccurate to some extent; data we get by measuring must be subject to fortuitous error, and may be subject to systematic error due to the system of measurement—instruments may be wrongly calibrated, and so on. Fortuitous error may be made definite by the application of the theory of probability, provided, of course, that the necessary work is done in the experiments; and we may take from this application the information that the true values (but still affected by systematic causes) of the quantities lie within limits of probable error—more probably so than not—the probability of a value being the true one decreasing very rapidly outside these limits, as indicated by the well-known frequency curve. It is much to be regretted that in many researches, even of the classical kind, no attempt is made to assign limits of probable error. In an example which has come under the writer's notice this was not done, although repeated measurements at each datum point were made, with the result that a very laborious research is rendered very much less valuable than it would have otherwise been. The effects of this lack of system are usually not very apparent at the time the research is made; it is only when the matter comes to be looked at from a new standpoint, or examined for residual phenomena, that the absurdity of giving such figures as accurate without a statement of probable error becomes apparent. This, of course, applies to those measurements which form the connecting-link between theory and the things that happen; many practical experiments are made under a well-understood convention as to negligible error.

5. In a graph such information as to probable error could be conveyed by giving a band (twice the probable error in vertical width) instead of a line for a curve, or a row of vertical lines instead of a series of dots for datum values (that

* See sections 10 to 15.

is, supposing all the error attributable to the values of Y—*i.e.*, where values of X may be taken as accurate for the purposes of reasoning, as we always suppose).

6. It is obvious, however, that systematic, or what we may call instrumental, error must be eliminated or it will infallibly render any reasoning wrong which is based on the results, provided, of course, that the error be sensible in amount.

7. While the graph forms a very complete representation of the observed facts, and indicates interpolation in the case of datum observations, and in the hands of a person of clear insight may often be the means of reasoning which may not be practicable or even possible by the more formal means of algebraic symbols, yet it is clearly necessary to find, if possible, some formula or function of X which will stand for the graph as well as may be. There are many reasons for this, the chief theoretic one being the enormous developing-power of the algebraic calculus.

8. In the preceding we have considered the graph as the most natural mode of recording phenomena of variation, but we may have occasionally inferential reasons for believing that the phenomenon should follow some particular function of X more or less completely, and it is necessary to examine the rationale of the functions in various cases.

(*a*.) A function may be logically applicable to a phenomenon. For instance, formulæ which state the results of definition, or those which state such inferences as that the angles in a plane triangle are 180°, may be regarded as truly applicable. Even this class may be subject to systematic instrumental error.

(*b*.) Functions in which there are strong inferential grounds for the belief that they express the substantial truth. For instance, formulæ deduced from Newton's laws of motion may be expected to apply closely to the motion of the major objects of the solar system; but experiments of an accuracy greater than those upon which such laws were founded may always be apt to demonstrate that the functions are not strictly applicable to any given phenomenon, and that there are systematic residual causes which should be taken into account.

(*c*.) Functions which have some inferential foundation, but the substantial applicability of which it is worth while to question and examine.

(*d*.) Functions whose foundation is largely hypothetical. This class we may term "empirical."

(*e*.) Functions which have no foundation except, perhaps, certain notions of continuity in rates of change, and so on. This class we may term "arbitrary."

9. It is intended to confine our attention chiefly to the example, of the last or last but one class, which is called the "power-expansion" or "Taylor's series formula."* It is, however, intended that the objections to the use of an arbitrarily systematic mode of computation should apply to all classes with respect to systematic instrumental error, and to all but the first with respect to the effect of systematic residual causes which are not allowed for in the function, or of any mistake or incompleteness in the inferring of the function.

10. Besides the curve and the datum-point graphs, we need to mention an intermediate class—namely, that of experiments which are arranged to give data for many points of X without any attempt to obtain repeated measures at any one point.

11. We might venture to define the characteristic virtues of the two main types of graph by saying that the curve yields a clear idea of the continuity of a phenomenon without allowing any great accuracy to be obtained in the measures of Y, while the datum point allows great accuracy to be attained in the measures of Y, and also permits definiteness to be attained in probable error, but leaves the interpolation to be judged. It may be put also thus: the curve gives a notion of dY/dX, the datum of Y. It is sometimes possible to form a graph of both kinds of measures—to measure accurately datum points and also to get the slope of the curve near these points. This procedure is analogous to that of constructing mathematical tables where datum points are often computed exactly and intermediate points found by Taylor's theorem. By such means very full information would be given of the actual phenomena.

12. A graph of the above-mentioned intermediate class, while it combines the virtues of both main forms, combines also their defects. In contemplating such a graph one would feel more content if a likely value for probable error at a few points of X were provided by the experimenter. The difficulty with this form of measurement is the very large number of measures necessary—theoretically a double infinity.

13. It is perhaps desirable to point out that in datum measurements we usually cannot get either X or Y exactly the same for each measure, accordingly we have to interpolate the values of Y to one common or mean value of

* It is to be observed that, in the case of functions the Taylor's series expansion of which are sufficiently convergent when applied to the experimental range, the result of the application of such a formula is practically identical with the result of the application of an unexpanded function of any class.

X (which we are going to take as absolutely accurate, theoretically). It is common to take the mean of both quantities, a process that often leads to the use of a few more decimal places. A more satisfactory process is to either measure dY/dX or else estimate it from antecedent knowledge of the likely curve, and then make a graph of the measures of each datum point and analyse it by means of the curve of dY/dX, which will be usually a straight line. From this we can get the probable (fortuitous) error, and also make a note of discordances, which is not always possible when the mean merely is taken.

14. A further advantage lies in the fact that we can avoid taking the mean value for X, and take instead a convenient adjacent value which has few integers, the last few significant figures being made noughts. This affords a vast saving in tabulation and in computation.

15. It may be thought by some that such matters as are being advanced are refinements for which time is too short; but the writer would appeal to those who may have honestly tried to get a reliable value for any physical constant which is not absolutely simple or else fundamental—even a there or thereabouts value—whether an enormous amount of labour has not been absolutely wasted by the neglect of such principles.

Least Squares.

16. An assertion will now be given which it is believed can be substantiated by reference to some recent text-books—that if a formula be applied to the results of observation so that the sum of the squares of the residual quantities or deviations of observed quantities from those calculated is a minimum with regard to the constants of the formula, then this formula may be referred to as the best, or even the most probable, and, in fine, that such application is a strictly scientific process. It must not be supposed for a moment that it is intended to convey that this view is held by accurate thinkers, but simply that it is observable that others have been led by the beauty of the method, and the very evident desirability of possessing a method of computation which should be free from personal bias, into an unwarrantable and indiscriminate promulgation of the formal procedure of the method.

17. There are two distinct objections to the mode of computation which has been described, and which it is hoped may be described as "least squares" without misunderstanding—namely: (1) That least squares observably tends to eliminate the application of the judgment to the indications of a graph, and, further, that it tends to make systematic deviations

look as much like true errors as possible; and (2) that the computations of least squares are often prohibitively laborious, thus practically preventing the analytical application of all sorts of formulæ which it may be easily possible to apply by other means.

18. The first objection will be illustrated by a couple of examples. Suppose we had a graph which consisted of the curve of a phenomenon following exactly (although the computer is not aware of this) a power-expansion formula of four terms, or cubic; and for certain reasons—say, the labour of least squares—are unable to use a formula of more than three terms, or parabolic. Then it can easily be seen, or proved, that least squares (which becomes a problem in integration in the case of a continuous curve) leads to a symmetrical arrangement of the deviations the proportions of which are shown in Graph A. It is pretty clear that for the observed range this arrangement of deviations strikes a good average; but conceive extrapolation to be necessary, or even a terminal value to be an important physical constant, would it not be preferable to accept the notions which one gathers from the shape of the curve and to extrapolate by means of some such freehand curve as is drawn dotted? The answer seems obvious enough when put in this way, and yet an almost precisely analogous condition of things has been the cause of considerable error in a certain oft-quoted classical research which the writer is recomputing by the graphic process.

19. A still more conclusive example is contained in the very common case of a few datum points representing the only observed facts. Here a physicist will often feel justified in drawing a curve for interpolation, and will have a very strong conviction of the unlikelihood of certain other curves which are much different from one he might draw. If least squares is followed up it is obvious that it leads to an exact representation of n datum points in a formula of n constants. In the case of the power-expansion formula the solution is identical with that of simultaneous equations. Graph B shows the least-square curve passing through six points—at $X = 0$, $0{\cdot}2$, $0{\cdot}4$, $0{\cdot}6$, $0{\cdot}8$, and 1, Y being zero at all points except $0{\cdot}6$. The indeterminate question to be here answered is whether there are any particular virtues about the least-square curve as compared, for instance, with the dotted curve (which was made by a flexible spring passing over rollers at the points). Is not the interpolation here very questionable, and the extrapolation doubtful in the utmost? It may be here remarked that the extrapolation of such formulæ of high degree is always very doubtful, except when there is a strong convergency.

20. We have here got two clear examples of what least squares leads to. In the first case, that of the curve, as we shall afterwards see, the shape of the curve of deviations is most strongly indicative of the need for the application of a formula of four terms, if not more. We have drawn the deviations according to least squares, which may be proved to arrange the deviations (given simply the direction of the axis of X) from a cubic phenomenon to which a parabola is applied, and where the observations are at nearly equal intervals of X, with a symmetry similar to that of the graph. The deviations, it will be observed, run $\pm(-, 0, +, 0, -, 0, +)$. By the graphic process we should arrange the parabola so that they run $\pm(0, +, 0, -, 0)$—so that, in fact, they bear a close resemblance to the standard cubic of Graph II. It is asserted that there is less likelihood of systematic deviations so arranged being mistaken for fortuitous errors than is the case with the least-squares arrangement. It may be again mentioned that this example is not, in its general features, a mere hypothetical case.

21. In the second case, that of six data, we have got a curve from our least squares which we have asserted to be quite unjustifiable, and not to be compared with the results that one would get from a common-sense judgment of the graph—not to be compared, that is, in avoiding rash assumptions as to the truth of the matter.

22. Following our definition of least squares, we have neglected to take any account of fortuitous probable error in these examples, but its vital necessity in such cases will be sufficiently obvious from what has been said in previous sections. The effect of probable error in the graph is to obscure the true points or line of the true curve of the phenomenon. When this occurs to such an extent as to hide any system there may be in the deviations, then, provided we are quite sure that our formula is substantially accurate compared with the scale of the probable errors, we might reasonably employ least squares to systematize our computations. This is a matter which is dependent upon circumstances, and more on judgment, and we believe that the employment of the latter will be found to be very largely dependent upon whether the treatment of empirical formulæ is taken as a mere extension of the beautiful applications of the theory of probability to astronomy and surveying or as a most important branch of the graphical calculus. This part of the subject is too complicated to treat of here except by suggestion, but we may refer to the example in Dr. F. Kohlrausch's work (see section 38), where a case of this complicated kind is given as if it were a simple and logical application of least squares; and where, moreover, the data are deliberately subjected to extra-

polation to the extent of half the observed range. It will be observed that we do not say that in this example anything better than is done by least squares could be done with such data, but we do say that it is absolutely misleading as an example of experimentation and of computation.

23. It is now necessary to draw attention to some theorems in the graphical calculus in which the combination of such curves as correspond to functions of the algebraic calculus is treated. X is the variable, A, B, &c., the (variable) constants. Suppose we have a curve whose function is—

$$F(X) = f_1(X) + f_2(X) + \text{(other similar terms)},$$

then we may build up the curve of F(X) by drawing the curves $f(X)$ all to the same scale, and then adding their ordinates at corresponding points of X. This is the theorem of sliding, for we conceive the ordinates of each of the component curves (of $f(X)$) to be capable of being slid over one another parallel to themselves, or to the axis of Y, and we so slide them that they are placed end to end, when we have the ordinates of the curve of the additive function F(X); then always, if we have found enough ordinates, we can complete the curve by freehand drawing, or even by eye without drawing.

24. Next we have the theorem of one-way stretch of ordinates, by which we can introduce variation in the constants of additive functions which are linear in the said constants. Thus, considering one term of the additive function F(X), and writing it with its constants displayed, its expression is $A.f(X)$. The theorem is that if we draw the curve of this function, making A take a convenient standard value—say, unity—we can find the ordinates corresponding to any given value of A by the use of some such device as proportional compasses applied to the curve we have drawn. So also with other similar terms. There is a curious point with these constants which had better be pointed out to prevent confusion—namely, that it is immaterial whether any algebraic relationships (independent of X variation) exist between them or not, provided that each is not fixed by any combination of the others, but is capable of taking up independent values. Such relationships should be studied, however, with a view to facilitating the graphical work. Thus, if two terms are $f_1(X,A)$ and $f_2(X,\overline{A,B})$, then we may have reason to prefer to take them as $f_1(X,A)$ and $f_2(X,C)$, or as $f_3(X,A)$ and $f_4(X,B)$, in the latter case breaking up the second function. Considerations such as these may be traced in the process for Taylor's series formulæ.

25. This is all we shall need for the Taylor's series analysis, but we may refer to text-books on least squares

for the application of Taylor's theorem to the approximative treatment of non-linear functions, and mention two other theorems of the graphical calculus which are of occasional use. In cases where X (or Y) is invariably associated with a constant by addition or by multiplication we get possible graphical operations, for, if the expression is $f(\overline{X + A})$, we may draw a curve to $f(X)$ and then introduce the effect of any value of A by shifting the curve bodily along its X axis; and so also with regard to Y. In the case of multiplication we get a stretch of a drawn standard curve in either one way or in two ways. For, to take the latter case, when $f_1(\overline{A \times Y}) = f_2(\overline{B \times X})$, having drawn a standard curve to convenient values of A and B, we get the effect of any values of either constant by uniformly stretching the curve in directions parallel to both axes. This can be effected by means of throwing shadows, and appears of value in our subject, since the frequency curve is of this form (with an immaterial relationship between the constants).

26. Reverting to the question of appealing to the judgment to detect systematic deviation from a formula, we see that we expect the deviation to become evident as a recognisable additive curve—*i.e.*, as if it were representable by a term $f(X)$. Clearly, this is frequently the case even where the deviations may be logically functions of Y, as, indeed, we supposed all errors to be in section 5; for, in a graph, if a function of X be represented, the corresponding function of Y is also automatically represented by the curve. By such means we can sometimes form an estimate of causes of error or deviation, and sometimes also—as we shall see in the case of the Mississippi Problem—be able to form an idea whether it is any use or not to go on complicating the particular formula which we are employing. When our resources are practically exhausted we shall give our formula, together with a statement of its range and the relation between probable (fortuitous) error and observed deviation, exhibiting the latter quantities in a graph of deviations, and leave it for others to judge what degree of likelihood attaches to our formula. Circumstances may lead us to employ least squares, but the value of our experiments cannot be adequately indicated unless we provide at least the equivalent of the details mentioned.

A Graphic Process for applying Power-expansion or Taylor's Series Formulæ.

27. A process will now be described by which it is very easy to graphically apply to date formulæ of four or even five terms in ascending powers of the variable.

28. It follows from Taylor's theorem that, if we use a

formula of n terms to approximate to a given curve, we obtain exactly the same choice of approximations whatever the scale of the variable may be or wherever its origin may be. We may therefore elect to make the experimental range unity in a new variable, and make the beginning of the range the origin. Thus, if the experimental variable X ranges from p to $p + q$, we take as a temporary variable $x = \frac{X - p}{q}$. It may be noted that in the case of a continuous function the corresponding Taylor's series becomes—

$$Y = Y_p + \left[\frac{q}{1}\left(\frac{dY}{dX}\right)_p\right] . x + \left[\frac{q^2}{1.2}\left(\frac{d^2Y}{dX^2}\right)_p\right] . x^2 + \&c.$$

29. If this expression were very convergent our analysis would lead us to the values of the bracketed quantities. Since, however, curves in general cannot be said to be representable by continuous functions, and particularly convergent ones, we cannot expect to make this conception of curves being built up of the effects of initial rates of change our basis of operations. We may with great convenience utilise the average rates of change for the whole range. Something of the sort is done in using an interpolation-table method, such as that given in "Thomson and Tait" (1890, i., p. 454).

30. The graphic process consists in taking for the first term the initial value of Y as given by the graph; for the second the average rate of change for the whole experimental range; for the third the average curvature for the whole scale expressed in terms of a parabola; for the fourth the difference in curvature of the first and second halves of the range expressed as a cubic standard formula; and so on. Up to the fourth term at least there is no difficulty whatever in keeping the effect of each of these three operations in the mind, and in forming one's conclusions whether a certain formula is as good as can be possibly got. The standard formulæ which the writer has used for this purpose are for the parabola $(x - x^2)$, and for the cubic $(x - 3x^2 + 2x^3)$. This is as far as we shall go for the present, but a table is given of some standard functions which might be used up to x^8 (or formulæ of nine terms) if one were clever enough to perform the work with all of them at once, or under special circumstances. These formulæ will be reverted to again.

31. The practical work is now very simple. We draw the graph of the experiments in terms of the temporary variable (which we should have mentioned is better not arranged to have its scale exactly equal to that of the experimental variable, but as nearly as is practicable, keeping p and q

simple numbers for convenience in conversion),* and then, provided with a scale to measure the constant term, a straight-edge to produce linear terms and drawn curves of the standard parabolic and cubic, and with a protractor or proportional compasses, we proceed to build up a curve the ordinates of which are added proportions of each of these four constituents, till we get a curve that is as nearly like the given one as possible. It will be quite obvious when this is done that we have a most clear idea of the prospective advantages of any other cubic formula whatever, and that we can arrange the deviations in any desired way—for instance, to arrange them for the application of a quartic formula, if it appears that such a course is advisable. We shall also develope a decided opinion on the subject of the application of common-sense to the resultant curve of deviations, both for interpolation and for extrapolation, and for residual causes or for error in the theory of the formula. In cases where the accuracy of the figures is great it may be necessary, after a rough analysis, to replot the deviations to a larger scale, so as to get over the limited accuracy practicable in a graph.

32. Many details will become obvious if a trial is made, and we need not pause over them; but it may be mentioned that the process is obviously applicable to all such formulæ as are made up of sums of terms each of which is linear in and contains only one constant. So the process might be arranged for harmonic analysis, or for the solution of simultaneous equations, and so on. The process is approximative, so that it is of indefinite accuracy, and is limited solely by the power of the judgment to indicate what alterations are desirable. The vast difference between this procedure and that of least squares will be apparent from the fact that we may be led to apply formulæ which have more terms or constants than there are datum points. This is due to the part we are allowing the judgment to play in controlling the interpolation.

33. The process is evidently susceptible of mechanical treatment, and the writer hopes to be enabled to construct a machine for this purpose.

34. With respect to the higher-power formula, there is a point which seems of theoretic interest in simplifying mathematical formulæ which are to be applied for a definite range (the converse of our experimental range), for, as is noted in

* It is to be noticed that in these formulæ the adjustment of the scale by introducing q is a perfectly simple matter of arithmetic; but to alter the zero point (p) is more troublesome, and should be avoided when possible. The Z functions of the Appendix afford an alternative range of -1 to $+1$, using the same curves.

the "Notes on the Graphs," the numerical values of these functions (even better formulæ may be obtained for this particular purpose) become very small, within the range, in comparison with the numerical value of the coefficient of x^n (that is, the highest power of x in the standard formula). This means that in the expansion as given in section 32, and when it is converging, we may for values of x from 0 to 1, by throwing the series into standard form, eliminate one or more of the higher-power terms, and so obtain an expression which is practically as accurate as the simple Taylor series, and is less in degree. The extent to which this may be expected to go is to be seen in the decreasing numerical or percentage values of the ordinates as the degree becomes large—with the octic it is already 1·3 parts in 10,000. Of course, in doing this we sacrifice all pretence to accuracy outside our defined range.

35. To sum up, we may emphasize the importance of the idea of the experimental range, as we have seen this leads to a great accession of power in the case of what we have ventured (not without precedent, of course, but, still, with some misgiving) to call "Taylor's series formulæ." An analogous idea is familiar enough in the "period" of the "Fourier series formulæ." Secondly, we venture to think that too much stress cannot be laid on the necessity for the statement of probable error in the individual data. This matter is strongly stated in the extract from Sir G. B. Airy's works given in section 38. Even the warnings of so great an authority as the late Astronomer Royal seem to have been greatly disregarded.

36. Thirdly, however plausible or apparently authoritative the theory of a physical phenomenon of variation may be, the experimental data upon it should be so prepared that the precise support given to the theory by the observations should be made evident, as can often be done by a graph either of the observations themselves or of the deviations from the aforesaid plausible theory, the graph exhibiting probable error in the way mentioned in section 5.

37. Finally, the writer wishes to disclaim any novelty in the foregoing, with one exception, and to apologize for lack of references, which are, indeed, very incomplete in Wellington. His object has been to collect a number of what he believes to be true although, no doubt, trite remarks, with the object of collecting an argument which he has been unable to find in any of the works to which he has access, and which is necessary for the development of another paper, to which reference has been made. The portion for which it is thought some novelty may be claimed is that of the treatment of the Taylor's series formulæ and similar linear

additive functions.* It is thought that the statement in Thomson and Tait's "Natural Philosophy" (ed. 1890, p. 454) of an interpolation method, and the reference to "a patient application of what is known as the method of least squares" in Professor Perry's "Calculus for Engineers" of 1897 (p. 18), form a sufficient ground for this conclusion.

Conclusion.

38. Those who may be inclined to question the necessity of such remarks as have been made upon an admittedly insufficient definition of least squares are recommended to examine, in the light of the considerations that have been advanced, the example of least squares put forth in Dr. F. Kohlrausch's work, English translation (called "Physical Measurements"), of 1894, from the German of 1892 (7th ed., chap. 3), and also Professor Merriman's "Theory of Least Squares" (1900 edition), with reference to Clairault's formula (about page 126), and from page 130 to the end of the Mississippi Problem. If, also, it is desired to observe how even legitimate least squares may lead to error, an examination may be made of the warnings of Sir G. B. Airy in the conclusion of his work on the "Theory of Errors of Observation, &c." (pp. 112, 113).† The 1874 edition of this work is available in the Public Library. A paper by F. Galton, F.R.S., in the "Proceedings of the Royal Society" of 1879, page 365, also contains a significant warning that the fundamental principle of the arithmetic mean is not always reliable. This should be considered in relation to the use of a curve of dY/dX in treating measures where X cannot conveniently be adjusted to the desired datum point for every observation.

39. We may also venture on the suggestion that, while many writers have been quite wrong in calling the constants of an empirical formula the "most probable ones," those who have called them "the best" merely may have been quite justified in making use of such an expression where it has not been shown that analytical resources of greater power are available, as has been the case with the Fourier series, and it is hoped will be now seen to be the case with the Taylor series and other linear additive formulæ. Further, the habit of referring to empirical formulæ as "laws" may have helped to give such formulæ an importance which, compared with the graph, they assuredly do not possess.

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* It should be mentioned, however, that Professor Callendar (Phil. Trans., 1887, p. 161) uses the formula of the standard parabola in connection with the reduction of platinum thermometry.

† In this connection see section 4.

APPENDIX.

I.

The "Mississippi Problem" is of some celebrity, and may with advantage be discussed. It refers to the velocity of the water at different depths in the Mississippi at Carrollton and Baton Rouge. The experiments were made in 1851, and were reduced by the experimenters by means of a parabolic approximation, which they applied according to common-sense principles similar to those of the present writer, except that they apparently did not perceive the bearing of the facts that are fundamental theorems in the graphical calculus (section 23). Consequently they failed to get such a good approximation to the experiments as is possible, although many engineers may think their approximation quite sufficient. Then in 1877* Professor Merriman, after referring somewhat caustically to "tedious approximative methods," proceeds to give a reduction by what he calls the "strictly scientific" method of least squares. This application is one to which our definition of least squares is strictly applicable. The calculations are given also in Professor Merriman's "Theory of Least Squares," 1900.

Again, in 1884, Mr. T. W. Wright, "Adjustment of Observations," page 413, reverts to the phenomena, applying both a parabolic and a cubic formula by least squares; and he remarks that, since the latter formula yields a smaller "sum of the square of the residual *errors*"—the italics are the present writer's—"the observations are better represented by the formula last obtained." From the graph of deviations obtained by the present writer he has no hesitation in saying that the indications are for the application of a discontinuous formula, the first section holding from depth 0 to 0·5 or 0·6, and the other from that to 0·9, the formulæ differing chiefly in the constant term. This reduces the deviations to $\frac{1}{2000}$, about, at most (judging from the graph), against about $\frac{1}{700}$ with the least-square parabolic. The value of the probable (fortuitous) errors is not given or discussed in either reference, so that it is quite a matter of speculation whether this indication of discontinuity is genuine or whether it is a mere matter of luck. At any rate, we should not attempt to improve such a graph by means of a cubic formula; it evidently would require a formula of a large number of terms to reduce the deviations to as small limits as those of the discontinuous parabolic. It is to be noted that all these considerations are obvious upon a mere inspection of a graph of the deviations which are given by Professor Merriman, and also that it is not suggested that

* Journ. Frank. Inst., C. iv., p. 233.

the motion of the water was discontinuous; more likely there are systematic instrumental errors. (See Graph C.)

II.

A few remarks may be made with respect to the arrangement of deviations in least-square form, the graphic process in the case of the power-expansion formula especially giving very convenient first approximations to the least-square values of the constants. If we take the expression "the mean" to signify that the algebraic sum of the deviations concerned is zero, and "the weighted mean" the same with respect to the deviations multiplied by datum values of certain weighting functions, then we may define least squares as the process which makes the weighted mean zero for all the weighting functions which can be obtained by differentiating the formula with regard to each of the constants separately and introducing the datum values of X. By writing down the equations which are needed to bring this about we obtain the normal equations of least squares, and we notice a valuable check on the correctness of a least-square reduction,* for in the power-expansion formula we see that the mean must hold, and also the weighted mean of the deviations, each multiplied by the datum values of x, of x^2, and so on to the last degree; or for x^2 we may substitute the standard parabolic, and so on. If, considering the formula to be in the standard terms, we examine a graph of deviations we can easily see that to approximate to least-square form we must take out all the amounts of standard components that will diminish the general magnitude of the deviations, but without allowing our judgment to come into play with regard to the run of any systematic deviation.

A little practice will often enable us to get such a close approximation to least-square form that the solution of the normal equations becomes much simplified. The normal equations, again, may be found more easily solved if made up in standard terms, for in examples similar to that of section 18 some of the coefficients in the normal equations tend to become zero, with formulæ of larger degree than the second—that is, using the formulæ of the "Notes on the Graphs."

III.

It is perhaps profitable to remark that, for the proper appreciation of a graph, we must get rid of the confusion that sometimes arises from the algebraical usage of making the symbols $-$ and $+$ stand for the operations of addition and subtraction and also as signs to designate whether a magnitude

* Given in Mr. T. W. Wright's book, page 144.

is positive or negative. The usage being as it is, we often in physical problems need to go back to the old arithmetical notion of negative quantities being impossible or imaginary, and consider the graph accordingly. For instance, take Taylor's theorem. It is usually expressed in one formula for the introduction of positive or negative increments; but Taylor himself (De Morgan, P. Cyc., p. 126) gave two formulæ, one for increments (or additions to x) and another for decrements (or subtractions from x). If now we take Maclaurin's form, we readily see that the second formula is impossible if we cannot reduce the magnitude or quantity to less than nothing.

Thus, to take a typical case, the magnetisation, or B–H, curve of iron, we cannot properly regard B and H as positive and negative quantities, but as direct and reverse positive magnitudes. A Taylor's series increment curve may then, perhaps, hold for magnitudes in either direction. If, however, we adhere to the algebraic usage, we shall be unable to express both of the symmetrical halves of the curve unless we employ only odd-power terms in our formula. This is obviously a very great disadvantage from a graphical point of view. As an indication of the contrary advantage it may be mentioned that a complete half of the sine curve can be built up of added proportions of the standard parabolic and quartic curves, with an extreme error of about 1 in 1,000 units, π radians forming the unit range of x.

Further, unless we adhere to the arithmetical notions, we are led to alternative values and imaginary quantities when, as in the example of the B–H curve may be desirable, we employ formulæ of fractional powers. Here the only alternative is to drop the fractions which have even denominators, which we can easily foresee may make formulæ of this class impracticable for arbitrary approximation to a curve.

To make clear what is meant, consider the expression $\sqrt{-1}$. Arithmetically -1 directs 1 to be subtracted from something which appears in the context. To take the square root of that which directs 1 to be subtracted from something else is evidently meaningless arithmetically. So also with $(-1)^2$, and so on. Algebraically we here take the symbol $-$ to indicate that the number to which it is attached is negative in quality or impossible arithmetically. This quality is also indicated by using a different symbol, i^{2n}, instead of $+$ and $-$, where i is an imaginary unit powers of which when combined with arithmetical symbols make quantities impossible in arithmetic. It is conventions as to the effect of powers of i upon the directions to add or subtract which enable us to perform calculations upon arithmetical quantities by algebraical methods with only occasional ambiguities.

Enough has now been said to guard against misleading use of the symbols $+$ and $-$ in graphical work.

Notes on the Graphs. (Plates XXXVI., XXXVII.)

Graph A gives the characteristic curve of deviations of a cubic-formula curve to which a parabolic approximation is applied (section 20); Graph B is that of section 21; Graph C that of the "Mississippi Problem," Appendix, I. Graph I. shows the curve of the standard parabolic and Graph II. that of the cubic. Graph III. shows two symmetrical quartics—(A), zero at $x = 0$, 1/3, 2/3, and 1, and having the formula—

$$(A) = 2x - 11x^2 + 18x^3 - 9x^4,$$

and (B), zero at $x = 0$, 1/4, 3/4, and 1, with formula—

$$(B) = 3x - 19x^2 + 32x^3 - 16x^4.$$

The maxima reach 0·11 and 0·25 respectively, or 1·2 and 1·6 per cent. of the numerical value of the coefficient of x^4. Graph IV. is a symmetrical quintic, zero at $x = 0$, 1/4, 1/2, 3/4, and 1, with formula—

$$(C) = 3x - 25x^2 + 70x^3 - 80x^4 + 32x^5.$$

Its maxima reach 0·11, which, the coefficient of x^5 being 32, represents 0·34 per cent. of the value of the latter. Graphs V., VI., and VII. are specimen standards of the hexic, heptic, and octic degree respectively. Their formulæ are given in the accompanying table. They are all made zero at the same points as the previous quintic. The curves all being symmetrical, about $x = 0·5$, are, as has been before noted, both simpler in form and more easy to compute values from if the origin of the abscissa is taken at $x = \frac{1}{2}$ and the scale of the variable halved. The formulæ are accordingly given in terms of $z = 2x - 1$, as well as in x—which is the most straightforward variable for common cases of a few terms.

It will be remarked that, so far as these standard formulæ have been developed, it has been arranged to keep the formula simple. In constructing formulæ for actual practice, however, it may be better to sacrifice the mathematical simplicity altogether in order to obtain curves that are convenient for the visual processes of analysis (see Postcript).

The percentage values of the maximum ordinates in these curves compared with the value of the coefficient of the highest power of x are as follows: Hexic, 0·39 per cent.; heptic, 0·03,5 per cent.; octic, 0·01,3 per cent. Thus, if we throw a formula into the standard form we can see what the effect will be if we throw away the highest term. It is evident that we shall often be able thus to reduce a formula of

a high degree to a simpler expression with very little error, but only for the range between the limits of the variable (original or transformed) 0 and 1.

SOME SYMMETRICAL STANDARD FUNCTIONS.

(Abscissa, x, or $z = -(1-2x)$.)

Term.	Formula in z or x.
Constant (x) ..	Unaltered.
Linear (z) ..	$+\frac{1}{2}(1+z)$.
" (x) ..	x.
Parabolic (z) ..	$+\frac{1}{4}(1-z^2)$.
" (x) ..	$(x-x^2)$.
Cubic (z) ..	$-\frac{1}{4}(z-z^3) = -\frac{1z}{4}(1-z^2)$.
" (x) ..	$+x-3x^2+2x^3$.
Quartic (z) ..	$-\frac{1}{4}(1-z^2)(1-4z^2) = -\frac{1}{4}(1-5z^2+4z^4)$.
" (x) ..	$+3x-19x^2+32x^3-16x^4$.
Quintic (z) ..	$+\frac{1z}{4}(1-z^2)(1-4z^2) = +\frac{1z}{4}(1-5z^2+4z^4)$.
" (x) ..	$+3x-25x^2+70x^3-80x^4+32x^5$.
Hexic (z) ..	$-\frac{1}{16}(1-z^2)(1-z^2)(1-4z^2) = -\frac{1}{16}(1-6z^2+9z^4-4z^6)$.
" (x) ..	$+3x^2-22x^3+51x^4-48x^5+16x^6$.
Heptic (z) ..	$+\frac{z}{16}(1-z^2)^2(1-4z^2) = +\frac{z}{16}(1-6z^2+9z^4-4z^6)$.
" (x) ..	$+3x^2-28x^3+95x^4-150x^5+112x^6-32x^7$.
Octic (z) ..	$-\frac{z^2}{16}(1-z^2)^2(1-4z^2) = -\frac{z^2}{16}(1-6z^2+9z^4-4z^6)$.
" (x) ..	$+3x^2-34x^3+151x^4-340x^5+412x^6-256x^7+64x^8$.

POSTSCRIPT.—Since writing the above I have had occasion to employ formulæ of more than four terms, and certain practical points have come to light. Suppose the graph consists of a "smooth curve," or, if it is of the datum-point variety, a smooth curve can be satisfactorily drawn through the data, then the analysis may proceed as follows: The constant, linear, and parabolic (standard) terms are obtained as before, and we draw in the base-line corresponding to this formula of three terms. Thus we have reduced the deviations to zero at $x = 0, \frac{1}{2}$, and 1. We then scale off the deviations from this formula at $x = \frac{1}{4}$ and $\frac{3}{4}$, and then, using the standard cubic and a quartic the formula of which may be $x(1-x)(1-2x)^2$, and which is obviously zero at the same three points as the cubic, we compute the amounts of these functions required to reduce the deviations to zero at the quarter points of x.

If further approximation be desired, the next systematic step would be to reduce the deviations at the odd-eighth points of x by means of quintic, hexic (somewhat different from the tabulated sample, obviously), heptic, and octic functions; and so on.

The same operations might possibly be considered easier if performed by simple algebra, but we should then lose the analytical power of judgment which is the vital advantage of the "standard" method.

With reference to the computation of values of Y from formulæ, the values of the standard functions up to the quartic degree may be computed by writing down the datum values of x; $(1 - x)$; and $(1 - x) - x$, or $(1 - 2x)$, and forming the proper products. Up to the octic degree we should need also $(1 - 4x)$ and $(3 - 4x)$, or $2(1 - 2x) \pm 1$. It is clear that if computation is to proceed by means of an arithmometer the labour of computation will not materially differ from that in which simple powers are used. With logarithms it will be necessary to enter the table once extra for each factor required.

Art. LIV.—*List of Papers on New Zealand Fishes and Fishing*.

By A. Hamilton.

[Laid before the Otago Institute, 12th November, 1901.]

[Note.—In the following list "Trans." means the "Transactions of the New Zealand Institute."]

Author.	Title.	Name of Publication.
Arthur, W. ..	On the Brown Trout introduced into Otago	Trans. xi. 271.
	Notes on some Specimens of Migratory *Salmonidæ*	" xiii. 175.
	On the History of Fish-culture in New Zealand	" xiv. 180.
	On Diseased Trout in Lake Wakatipu	" xv. 198.
	Notes on the New Zealand Sprat	" xv. 203.
	Notes on the Picton Herring ..	" xv. 208.
	On the Brown Trout introduced into Otago	Trans. xvi. 467; also N.Z. Jrnl. Sci. iii. 36.
	Notes on New Zealand Fishes	Trans. xvii. 160.
	Notes on the New Zealand Frost-fish	N.Z. Jrnl. Sci. iii. 157.
Beattie, J. M. ..	On the Anatomy of the Red-cod (*Lotella bacchus*)	Trans. xxiii. 71.
Benham, W. B. ..	On the New Zealand Lancelet (*Heteropleuron*)	" xxxiii. 120.
Bleeker, Pieter ..	Over eenige Visschen van Van Diemensland	Amsterdam, 1855.
Campbell, W. D.	On a New Fish (*Discus*, gen. nov.)	Trans. xi. 297.
Canavan, E. O'H.	On Eels	" xxv. 191.
Chapman, F. R...	Handbook of Laws relating to Acclimatisation, Fish, Fisheries, and the Protection of Animals and Birds	Dunedin, 1892.
Cheeseman, T. F.	Notes on the Sword-fish ..	Trans. viii. 219.
Clarke, F. E. ..	On Two New Fishes	" x. 243.
	On some New Fishes.. ..	" xi. 291.
	On a New Fish found at Hokitika	" xi. 295.
	Description of a New Species of *Trachypterus*	" xiii. 195.

Author.	Title.	Name of Publication.
Clarke, F. E. ..	On Two New Globe-fish ..	Trans. xxix 243.
	On the Occurrence of a Species of *Lophotes*	„ xxix. 251.
	On the Occurrence of *Regalecus argenteus*	„ xxx. 254.
	On the New Zealand species of *Galaxias*, more especially those of the Western Slopes	„ xxxi. 78.
	On *Exocœtus ilma*, a New Species of Flying-fish	„ xxxi. 92.
	Notes on Parore (the Mangrove Fish)	„ xxxi. 96.
Colenso, W. ..	Notes on the Genus *Callorhynchus*, with a Description of an Undescribed New Zealand Species	„ xi. 298.
Drew, S. H. ..	Notes on *Regalecus* sp. ..	„ xxx. 253.
	On a Sun-fish (*Orthagoriscus mola*)	„ xxix. 286.
Duigan, James ..	Is Access to the Sea a Necessity to Eels?	„ viii. 221.
Douglas-Ogilby, J.	Description of a New Pelagic Fish (*Centrolophus*) from New Zealand	Rec. Aust. Mus. ii. 62.
Ferguson, Alex. ..	On the Causes of the Disappearance of Young Trout from our Streams	Trans. xxi. 235.
Forbes, H. O. ..	On a New Genus of Fishes of the Family *Percidæ* from New Zealand (*Plagiogeneion rubiginosus*, Hutton)	„ xxii. 273.
	On a Species of *Regalecus* ..	„ xxiv. 192.
	On the Great Oar-fish ..	N.Z. Jrnl. Sci. n.s. i. 154
Forster, Johann Reinhold	In Bloch's "Systema Ichthyologiæ"	Berlin, 1801.
	Descrip. Animalium quæ in itinere ad maris Australis terras observavit. Cur. Lichtenstein	Berlin, 1884.
Gill, Theodore ..	A Comparison of Antipodal Faunas	Nat. Acad. of Sci. vi.; and Mem. Acad. Washington, vi. 91.
	On the Genera *Labrichthys* and *Pseudolabrus*	Proc. U.S. Nat. Mus. xiv. No. 861.
Gillies, T. B. ..	On the Introduction of Trout to New Zealand	Trans. v. 456.
Gunther, A. ..	Notes on *Prototroctes*, a Fish from the Fresh Waters of the Australian Region	Proc. Zool. Soc. Lond. 1870.
	Remarks on New Zealand Fishes	Trans. ix. 469.
	„	Ann. and Mag. Nat. Hist. (3rd ser.) vii. 85.
	„	Ann. and Mag. Nat. Hist. (4th ser.) xvii. 389.
	In "British Museum Catalogue of Fishes"	1859–90 and 2nd ed. 1899.

Author.	Title.	Name of Publication.
Gunther, A. ..	Report on the Shore Fishes procured, Voyage H.M.S. "Challenger"	Chall. Rep. i. 27.
	Report on the Deep-sea Fishes procured, Voyage H.M.S. "Challenger"	" xxii.
Gray and Richardson	In "Dieffenbach's New Zealand"	ii. 206.
George, Seymour T.	Notice of the Capture of a Large Stingaree (*Trygon thalassia*)	Trans. xiii. 426.
Garman, S. ..	*Myxine australis*, Jen. (redescribed and figured)	Mem. Mus. Harvard, xxiv. 345.
Haast, Sir J. von	Notes on some Undescribed Fishes of New Zealand	Trans. v. 272
	On *Cheimarrichthys forsteri* ..	" vi. 103
	On the Occurrence of *Lamna cornubica* in New Zealand	" vii. 237.
	On the Occurrence of *Leptocephalus longirostris*, Kaup., on the Coast of New Zealand	" vii. 238.
	Notes on *Regalecus pacificus* ..	" ix. 646, x. 246.
Hamilton, A. ..	Notes on a Large Sun-fish (*Orthagoriscus mola*) recently captured at Napier	" xviii. 135.
	Rare Fishes (Torpedo) ..	N.Z. Jrnl. Sci. i. 465.
	Notes on some Napier Fishes ..	" iii. 127.
Hanson, A. ..	Notice of a Giant Sun-fish (*Orthagoriscus mola*) cast ashore at Cape Campbell	Trans. xx. 447.
Heath, Neil ..	On the Effect of Cold on Fishes	" xvi. 275.
Hector, Sir James	On the Mud-fish (*Neochanna apoda*), from Hokitika	" ii. 402
	On a Species of *Ophisurus*, from the Coast of New Zealand	" ii. 34.
	On a New Species of Fish, *Coryphænoides novæ-zealandiæ*	" iii. 136
	On the *Salmonidæ* of New Zealand	" iii. 133.
	Notes on the Edible Fishes of New Zealand (in the Catalogue of the Fishes of New Zealand, by Captain Hutton)	1872.
	Introduction of English Trout into Wellington, and Mention of New Fishes	Trans. iv. 379.
	Notice of *Motella novæ-zealandiæ*	" vi. 107.
	Notes on New Zealand Ichthyology	" vii. 239.
	Regalecus gladius, and other Additions to the Colonial Museum	" x. 533.
	Descriptions of Five New Species of Fishes obtained in the New Zealand Seas by H.M.S. "Challenger" Expedition	Ann. Mag. Nat. Hist. (4th ser.) xv. 78.

Author.	Title.	Name of Publication.
Hector, Sir James	Notes on New Zealand Ichthyology	Trans. ix. 465.
	Notes on New Zealand Ichthyology	Ann. Mag. Nat. Hist. (3rd ser.) xix. 339.
	Notice of a New Fish ..	Trans. xiii. 194 and 436.
	Notice of a New Fish ..	„ xiii. 195.
	On the Occurrence of Salmon-trout in Nelson Harbour	„ xiv. 211.
	Reported Capture of a Californian Salmon at Riverton	„ xiv. 545.
	Notes on New Zealand Ichthyology	„ xvi. 322.
	On a Small-sized Specimen of the Hapuka, *Hectoria (Oligorus) gigas*, Castelnau, caught in Wellington Harbour	„ xx. 446.
	On Acclimatised Salmon and Trout	„ xxv. 539.
	On a New Species of Luminous Fish (*Polyipnus kirkii*)	„ xxviii. 743.
	Mullet Protection	App. Jour. H. of R. Sess. II. 1897. H.-17.
	Further Papers relative to the Fisheries of the Colony	App. Jour. H. of R. 1869. D.-15.
	Remarks on a Supposed Specimen of *Salmo salar*	Trans. xxxiii. 562.
Henry, Richard ..	On Dusky Sound (fishes, &c.) ..	„ xxviii. 50.
	Notes on Fish	App. Jour. H. of R. Sess. II. 1897. C.-1, 128.
Hombron and Jacquinot	Voyage au Pôle Sud par Dumont D'Urville (Poissons)	1853–54.
Hutton, F. W. ..	On the Occurrence of the Sprat and Anchovy at the Thames	Trans. v. 449.
	Fishes of New Zealand: Catalogue, with Diagnoses of the Species, with Notes on the Edible Fishes by James Hector	1872.
	Contributions to the Ichthyology of New Zealand (Supplement to the "Fishes of New Zealand")	Trans. v. 259.
	Notes on some New Zealand Fishes	Ann. Mag. Nat. Hist. (4th ser.) xii. 400.
	The Geographical Relations of the New Zealand Fauna	Ann. Mag. Nat. Hist. (4th ser.) xiii. 95
	Note on a Sea Trout caught in Otago Harbour	Trans. vi. 447.
	Contributions to the Ichthyology of New Zealand	„ vi. 104.
	Description of a New Species of New Zealand Fish	Ann. Mag. Nat. Hist. (4th ser.) xvi. 313.
	Contributions to the Ichthyology of New Zealand Fishes	Trans. viii. 209.
	Contributions to the Ichthyology	„ ix. 353.

Author.	Title.	Name of Publication.
Hutton, F. W. ..	Notes on a Collection from the Auckland Island and Campbell Islands (fishes)	Trans. xi. 339.
	Description of a New Fish (*Labrichthys roseipunctata*)	" xii. 455.
	List of the New Zealand Fishes	" xxii. 275.
	Notes on some New Zealand Fishes, with Description of a New Species; and a Synopsis of the New Zealand Species of *Galaxias*	" xxviii. 314.
Jenyns	Voyage of the "Beagle" (Zoology)	1842.
Jouan	Essai sur la Faune de la N.Z.	Mem. de la Soc. des Sci. Nat. de Cherbourg, xiv. 295.
Kingsley, R. I. ..	On a Specimen of the Great Ribbon-fish (*Regalecus argenteus*) taken in Nelson Harbour	Trans. xxii. 333.
Kirk, T. W. ..	Additions to the List of New Zealand Fishes	" xii. 308.
Kner	Reise der Oesterreichischen Fregatte "Novara" (Fische)	1869.
Knox, F. J. ..	On the New Zealand Sword-fish	Trans. ii. 13.
	Anatomical Observations on *Ophisurus* sp.	" ii. 34.
	Note on *Ctenolabrus knoxi* ..	" v. 308.
	On *Coridodax pullus*	" iii. 130.
	On the Anatomy of the Kanae (*Mugil* sp.)	" iv. 189.
	Observations on an Albino Eel	" iv. 378.
Lesson	Voyage de "la Coquille" ..	1826, 1830.
Lendenfeld, R. von	On *Lepidopus caudatus* (New Zealand Frost-fish)	N.Z. Jrnl. Sci. iii. 108.
Mair, Captain ..	Notes on Fishes in the Upper Wanganui River	Trans. xii. 315.
McCoy	In Trans. Royal Soc. Vict. ..	1864.
	In Ann. and Mag. Nat. Hist.	1865.
Parker, T. Jeffery	On the Venous System of the Skate (*Raja nasuta*)	Trans. xiii. 413.
	On a New Method of preserving Cartilaginous Skeletons	" xiv. 258.
	On the Gravid Uterus of *Mustelus antarcticus*	" xv. 219.
	Notes on the Anatomy and Embryology of *Scymnus lichia*	" xv. 234.
	On the Connection of the Air-bladder and the Auditory Organ in the Red-cod (*Lotella bacchus*)	" xv. 234.
	On the Occurrence of the Spinous Shark (*Echinorhinus spinosus*) in New Zealand Waters	" xvi. 280.

Author.	Title.	Name of Publication.
Parker, T. Jeffrey	On a Torpedo (*T. fusca?*), n. sp., recently caught near Dunedin	Trans. xvi. 281.
	On a Specimen of the Great Ribbon-fish (*Regalecus argenteus*), n. sp., recently obtained at Moeraki, Otago	" xvi. 284.
	Skeleton of porbeagle shark preserved by glycerine method exhibited	" xvi. 565.
	On a Specimen of *Regalecus* recently stranded in Otago Harbour	" xx. 20.
	Note on the Fœtal Membranes of *Mustelus antarcticus*, with an Analysis of the Pseudamniotic Fluid by Professor Liversidge	" xxii. 331.
	Preliminary Note on the Vesiculæ seminales and the Spermatophores of *Callorhynchus antarcticus*	Proc. Aust. Ass. Adv. Sci. (Hobart), 1892.
	On the Occurrence of *Lophotes* in New Zealand Waters	Trans. xxvi. 223.
	Note on a Specimen of *Orthagoriscus mola*	" xxix. 627.
	Remarks on *Regalecus argenteus*	" xxx. 574.
	On *Haplodactylus meandratus* and *Lepidothynnus huttoni*	" xxx. 575.
	Abstract of a Memoir on *Regalecus argenteus*	Proc. Zool. Soc. 207, 1884.
	Notes on *Carcharodon rondeletii*	" 27, 1887.
	Studies in New Zealand Ichthyology: I., On the Skeleton of *Regalecus argenteus*	Trans. Zool. Soc. Lond. xii. 5.
Powell, L. ..	On Four Fishes commonly found in the River Avon; with a Consideration of the Question, What is Whitebait?	Trans. ii. 84, 417.
	Notes on the Anatomy of *Regalecus pacificus*	" xi. 269.
Quoy and Gaimard	Voyage of the "Astrolabe" ..	1834.
Roberts, W. C. ..	On the Mud-fish (*Neochanna apoda*), being Extracts from Letters written by G. G. Fitz-Gerald and S. E. Vollams	Trans. v. 456.
Robson, C. H. ..	Notes on the Habits of the Frost-fish (*Lepidopus*)	Trans. viii. 218; also N.Z. Jrnl. Sci. ii. 289.
	Habits of the Torpedo Ray ..	N.Z. Jrnl. Sci. iii. 27, 123.
Rutland, Joshua..	On the Habits of the New Zealand Grayling	Trans. x. 250.
Richardson, John, and Gray, J. E.	List of Fish hitherto detected on the Coast of New Zealand, with a Description of the New Species brought Home by Dr. Dieffenbach	Dieffenbach: Travels in New Zealand, ii. 206.

Author.	Title.	Name of Publication.
Richardson, John	Report on the Present State of the Ichthyology of New Zealand	Rep. Brit. Ass. Adv. Sci. 1843, p. 12.
	Description of Australian Fishes, Parts I. and II.	Trans. Zool. Soc. iii. 69, 133.
	Description of Fishes ..	Voyage "Erebus" and "Terror," Zool. pt. ii. 1845–48.
	" ..	Voyage of the "Samarang" (Zool.) 1848.
Sandager, F. S. ..	List of Fishes found round the Mokohinau Islands, their Spawning-time, and Observations regarding some of the Species	Trans. xx. 127.
	Note on some Sea-trout ..	" xxv. 254.
Scott, J. H. ..	Cancer in Fish	" xxiv. 201.
Stenhouse, Andrew	On the Anatomy of the Pig-fish (*Agriopus leucopæcilus*)	" xxvi. 111.
Sherrin, R. A. A...	Handbook of the Fishes of New Zealand	Auckland, 1886.
Spackman, H. ..	Trout in New Zealand, and when to catch them	Government publication.
Thomson, G. M. ..	The Dunedin Fish-supply ..	Trans. x. 324.
	Our Fish-supply	" xi. 380.
	Parliamentary Paper, p. 21, H.-17, Sess. II., 1897.	
	Our New Zealand Fisheries, and the Desirability of introducing New Species of Fish	" xxviii. 758.
	The Proposed Biological Station and Fish-hatchery near Dunedin (Letter to Captain F. W. Hutton)	Aust. Ass. Adv. of Sci. 1898.
	Notes on the Occurrence, Habits, Weights, &c., of various Marine Fishes in New Zealand	Trans. xxiv. 202.
Travers, W. T. L.	On the Absence of the Eel from the Upper Waters of the Wai-au-ua and its Tributaries	" iii. 120.
	Notice of a Parrot-fish (*Odax vittatus*)	" v. 439.
	On New Zealand Fishes ..	*Nelson Examiner*, 26/10/1860.
Waite, E. R. ..	*Lampris luna*, Gml.: Its Occurrence in New Zealand Waters	Records of the Aust. Mus. 166.
Webb, J. S. ..	On a Fish of the Genus *Bovichthys*	Trans. v. 480.
Williams, W. L...	On a Sun-fish captured at Poverty Bay	" xxv. 110.

See also a bibliography of papers relating to "Die Fische Neu-Hollande, der Sud See, &c.," in "Die v. Müller'sche Sammlung Australischer Fische in Stuttgart," von Dr. C. B. Klunzinger, in lxxx. bande der Sitzb. der K. Akad. der Wissensch. i. Abth., nov. heft., 1879; a bibliography in the "Catalogue of New Zealand Fishes," by Captain F. W. Hutton, 1872; reports of the Acclimatisation Societies of Auckland, Canterbury, Hawke's Bay, Nelson, &c.; Parliamentary papers relative to the Fisheries of the colony, 1868 and 1869; and paper relative to the introduction of salmon into the colony (App. to Journ. H. of R., D.–2, 1869), which contains a few observations of the temperature of sea and rivers.

PARLIAMENTARY PAPERS RELATING TO FISH AND FISHERIES.

Acclimatisation Societies, Suggestions by a Conference of, at Dunedin. L.C. No. 2, 1883.

Bonuses paid for Fish exported. H.–45A, 1890.

Fish-breeding Establishment, Maintenance of a. H.–30, 1880.

Fish-culture, Report of Colonial Industries Commission on. H.–22, 1880, p. 86.

Oyster-cultivation, Report by W. H Pearson on. H.–13, 1877.

Oyster-fisheries Act, Bringing into Force the. H.–31, 1875.

Reports of Commissions on Fisheries. D.–15, 1869; D.–9, 1870.

Report of Industries Commission. H.–2, 1880.

Reports on Fisheries. D.–15, 1869; H.–15, 1885.

Salmon and Trout Fry, Distribution of, by Southland Acclimatisation Society. H.–7, 1876.

Salmon and Trout in Southland. L.C. No. 2, 1875.

Salmon, Trout, Herring, and other Fish, Introduction of. H.–7 and H.–7A, 1886; H.–3, Sess. II., 1887.

Salmon-trout, Introduction of. I.–4, 1873, p. 28.

Salmon, Introduction of. D.–2, 1869; G.–26 and G.–26A, 1872; H.–12, 1873; H.–8 and H.–8A, 1874; H.–14, 1877, H.–11 and H.–11A, 1878; H.–14A, Sess. II., 1879; H.–17, 1885; H.–7 and H.–7A, 1886; H.–3, Sess. II., 1887; H.–4, 1889.

Salmon, Whitefish, and Catfish, Report of Californian Commission on. H.–11, 1878, p. 14.

Scottish Fisheries Improvement Association, Extract from Report of the. L.C. No. 16, 1885.

Stewart Island Fisheries. D.–1, 1872, p. 25.

Temperature of Rivers and Sea in and about New Zealand. D.–2, 1869, p. 23.

Whitefish, Introduction of. H.–11, 1878; H.–14 and H.–14A, Sess. II., 1879; H.–31, 1880; H.–3, Sess. II., 1887.

Kaikoura Fisheries. D.–9, 1870, p. 5.

Fish and Oysters exported, April, 1891, to March, 1895. H.–21, 1895.

Flounders: Limit of Size to be taken. H.–10, Sess. II., 1891; H.–6, 1893.

Seal Fisheries, Report on. A.–1, 1893, p. 2.

Seals and Seal Rookeries in Auckland and other Islands. H.–25, 1894.

Sea-fisheries Act, Inspectors appointed and Craft registered under. H.–13, 1895.

Marine Department, Reports of. H.–30, Sess. II., 1891; H.–29, 1892; H.–31, 1893; H.–18, 1894; H.–29, 1895; H.–15, 1896.

Wairarapa Lakes and Adjacent Lands, Report by A. Mackay on Maori Claims to. G.–4, Sess. II., 1891.

Acclimatisation and Fisheries, Report on, by L. F. Ayson. H.–27, 1899.

Fisheries: Dunbar Marine Hatchery, Report on. H.–27, 1899.

Mullet, Protection of. H.–17, Sess. II., 1897.

Notes on Fish, by R. Henry. C.–1, Sess. II., 1897, p. 128.

Paper by G. M. Thomson. H.–17, Sess. II., 1897, p. 21.

"Fisheries Conservation Act, 1884," Regulations under. Order in Council, 7th March, 1885, and 2nd June, 1885.

PUBLIC GENERAL ACTS AFFECTING FISH AND FISHERIES.

Regulating fisheries, and for encouraging the establishment thereof. 1877, No. 45 (*a*); 1884, No. 48 (*a*).

For the conservation of fisheries. 1884, No. 48; 1887, No. 27. *Gazette*, 1885, pp. 380, 720; 1886, p. 529.

For the establishment of fishing towns, and promoting the export of canned or cured fish. 1885, No. 16; 1900, No. 31; *Gazette*, 1885, p. 1306; 1886, p. 1521.

Consolidating and amending the law relating to sea-fisheries. 1894, No. 56 (*b*); 1895, No. 39; 1896, No. 29. Regulations, *Gazette*, 1897, pp. 18, 885, 2113; 1898, pp. 367, 500, 1778; 1899, pp. 1051, 1592, 1867; 1900, p. 1737.

Oysters: Providing for the protection of oyster-fisheries, and a duty on the export of oysters. 1894, No. 56, ss. 7–10.

Prohibiting the use of dynamite or other explosives for the purpose of catching or destroying fish in public fisheries. 1878, No. 42, s. 3; 1884, No. 48; 1894, No. 56, s. 49.

(*a*) Repealed as to sea-fisheries. (*b*) Part ss. 3, 21, 47 repealed.

Salmon and Trout: Making provision for the preservation and propagation thereof in the colony. 1867, No. 34; 1884, No. 47.

Fresh fish may be sold by auction, without license, at any hour and in any manner customary in the trade. 1886, No. 10; 1891, No. 24, s. 30.

Fish-stealing. 1867, No. 3, ss. 24–26.

Fish-poisoning. 1867, No. 6, sec. 32.

NEW ZEALAND INSTITUTE

NEW ZEALAND INSTITUTE.

THIRTY-THIRD ANNUAL REPORT.

MEETINGS of the Board were held on the 19th and 26th November, 1900, and 6th September, 1901.

Messrs. Tregear, Young, and Sir J. Hector retired from the Board in compliance with the Act, and were all renominated by His Excellency the Governor. The following gentlemen were elected by the incorporated societies as Governors of the New Zealand Institute for the current year—namely, Mr. S. Percy Smith, Mr. Martin Chapman, and the Hon. C. C. Bowen.

The members now on the roll are—Honorary members, 26; Auckland Institute, 156; Hawke's Bay Philosophical Institute, 61; Wellington Philosophical Society, 154; Philosophical Institute of Canterbury, 72; Otago Institute, 106; Nelson Philosophical Society, 12; Westland Institute, 51: making a total of 638.

The volumes of Transactions now on hand are—Vol. I. (second edition), 225; Vol. V., 6; Vol. VI., 10; Vol. VII., 95; Vol. IX., 93; Vol. X., 123; Vol. XI., 23; Vol. XII., 25; Vol. XIII., 26; Vol. XIV., 48; Vol. XV., 160; Vol. XVI., 160; Vol. XVII., 162; Vol. XVIII., 128; Vol. XIX., 153; Vol. XX., 154; Vol. XXI., 85; Vol. XXII., 87; Vol. XXIII., 163; Vol. XXIV., 167; Vol. XXV., 162; Vol. XXVI., 172; Vol. XXVII., 168; Vol. XXVIII., 173; Vol. XXIX., 300; Vol. XXX., 350; Vol. XXXI., 400; Vol. XXXII., 400; Vol. XXXIII., not yet fully distributed.

The volume just published (XXXIII.) contains sixty-three articles, and also addresses and abstracts which appear in the Proceedings; it consists of 628 pages and twenty-three plates. The following is a comparison of the contents of the present volume and that for last year:—

	1901. Pages.	1900. Pages.
Miscellaneous	156	162
Zoology	264	62
Botany	70	102
Geology	10	68
Chemistry and Physics	38	16
Proceedings	44	38
Appendix	46	46
	628	494

The cost of printing Vol. XXXII. was £338 11s. 6d. for 494 pages, and that for the present volume (XXXIII.) £384 14s. for 628 pages. This includes the preparation and printing of the plates.

From the honorary treasurer's statement of accounts it appears that the amount received for the year was £961 11s. 8d., including the balance carried forward, and the expenditure £422 15s. 4d., leaving a balance in hand of £538 16s. 4d.

Owing to the unfortunate destruction by fire of Part V. of "Maori Art," considerable delay has been caused in issuing the complete work. The publication was again taken in hand, and Part V. will be delivered in the course of a week or so.

Museum.

There have been 120 entries in the books as additions to the Museum since last report, a list of which will be published in due course. The whole of the cases in the Museum have been cleaned and revarnished, and several important changes were made in the exhibits prior to the arrival of the Royal visitors, who inspected the collection. These changes afforded more space for the display of the specimens, and the large leading tickets were all renewed.

Library.—The books in the library have been classified and arranged so that they can be referred to without difficulty with the assistance of the new catalogue published last year.

Meteorological.

The returns of the principal stations for 1900 have been supplied as usual to the Registrar-General to be included in his annual statistics, and the monthly rainfall returns from 176 stations have been regularly published in the *Gazette*. The monthly return for vital statistics has been supplied, and the weather exchange, by telegraph, is continued between this colony and Australia.

Colonial Time-ball Observatory.

Mr. Thomas King, the officer in charge, reports as follows: The transit work in connection with the daily-time service has proceeded as usual. Details of the observations are appended hereto, together with particulars of the rates of the standard clocks. The clocks have gone well throughout the year. The transit instrument has, of course, been frequently tested for adjustment.

As in past years, hourly galvanometer signals have been sent from the Observatory to the Colonial Museum, and to the Telegraph-office, Wellington; and time has been distributed throughout the colony each morning at 9 o'clock. On chronometer-rating days special signals have, as heretofore, been telegraphed to the chief ports of the colony for the convenience of navigators. The time-ball at Wellington has been dropped each day at noon (Sundays excepted).

James Hector, Manager.

Approved.—Thomas Mason, Chairman.—6th September, 1901.

New Zealand Institute Accounts for 1900–1901.

Receipts.	£	s.	d.	*Expenditure.*	£	s.	d.
Balance	432	5	11	Printing Vol. XXXIII (including plates)	384	14	
Vote for 1900–1901 ..	500	0	0	Expenses of library	20	0	
Contribution from Wellington Philosophical Society	11	11		Postages of volumes to foreign addresses	2	17	
Sale of "Maori Art" ..	17	14		Miscellaneous items	15	4	
				Balance in hand	538	16	
	£961	11	8		£961	11	8

Examined and found correct.—Wm. Thos. Locke Travers.—5th September, 1901.

IN MEMORIAM.

William Skey, the late New Zealand Government Analyst, was born in London on the 8th April, 1835, and showed an early taste for chemistry, especially in its bearing on agricultural pursuits. On his leaving school he was put to learn practical farming, and, with his employer's son, built a laboratory in his spare time, for the purpose chiefly of trying the business of distilling spirits of wine from beet-root. A large quantity of the roots was contracted for, but, unfortunately, they were grown on peaty soil, and consequently only contained a small percentage of sugar, so that very little spirit was produced. This and other circumstances led to the abandonment of the enterprise, and in 1860 Skey, along with his brother Henry (now in the Survey Office at Dunedin), emigrated to New Zealand, where they spent some time on the Otago goldfields, which were discovered at that time.

Early in 1863 he was appointed Laboratory Assistant to the Geological Survey of Otago under Dr. Hector, in place of Mr. Charles Searles Wood, Associate of the Royal School of Mines, who received an appointment on the Geological Survey of Victoria. Mr. Skey continued Analyst to the Geological Survey Department of the colony for twenty-seven years, until 1894, when he was nominally transferred to the Mines Department, continuing, however, to work in the same old laboratory until within six weeks of his death, which occurred on the 4th October, 1900.

For thirty-eight years Mr. Skey served the Government, and with indefatigable industry applied his great talent for chemical research. The Laboratory register when he left off work showed entries which cover 12,416 separate analyses, more than ten thousand of which were performed by Skey. Outside his laborious official duties he made many original contributions to chemical science, such as improvements in laboratory appliances; the electrical properties of metallic sulphides; the discovery of the ferro-nickel alloy "awaruite" in the ultra-basic rocks of West Otago, which is highly interesting as being the first recognition of a meteoric-like iron as native to our planet; the discovery that hydrocarbon in oil-shales is chemically and not merely mechanically combined; the discovery of a remarkable colour-test for the presence of magnesia; and the isolation of the poisons of many native shrubs. His suggestions for purifying water-tanks in India, for the use of the hot-air blow-pipe in the laboratory, and for the application of cyanogen salts to gold-saving, were some of his early achievements, which are now in practical use all over the world. His discovery that fatty oils treated with anilines form alkaloids hints at an important new departure in organic chemistry.

These and many other practical applications of Skey's chemical talent are distinguished services to science, of which New Zealand should be proud. Without much training Skey, possessing a natural bent, developed by diligent labour and hard study, attained to such a position as to be recognised as one of the world's famous authorities in certain branches of chemical science.

In William Skey the colony has lost a good servant and an able scientific man. He used to say that chemistry, farming, and poetry were the three things he took most interest in, and would sit up all night in the Laboratory composing and printing his poetical fragments with a hand type-press.

Official List of Analyses reported by William Skey.

Coals and mineral oils	789
Metallic ores	1,480
Special for gold and silver ores	3,764
Rocks and minerals	2,764
Waters (mineral, &c.)	657
Miscellaneous (soils, manures, adulterations, Customs Department, Fiscal Department)	2,962
	12,416

Of these analyses more than ten thousand were performed by Skey.

The Report on the Mineral Exhibits in the New Zealand Exhibition, 1865 (Hector and Skey, Appendix, pp. 371–452) also contains a large amount of chemical work of great value to the colony which was performed by Skey.

Papers contributed to the New Zealand Institute by William Skey.

Absorption of Alkaloids by Silicates, V., 375.
" of Copper, IV., 332.
Alkalinity of Carbonate of Lime, II., 150; IV., 323.
" of Salts and Minerals, IV., 325.
Alkalies, Solubility of, in Ether, VIII., 338.
Allotropic Form of Zinc and Cobalt Salts, XIII., 387.
Analogy of Cyanogen to Oxygen, VII., 379.
Anthraconite, or Stinkstone, XXV., 379.
Approximate Composition of Winslow's Soothing-syrup, IX., 637.
Arsenic and Antimony, Absorption of, VIII., 337.
Argentic Sulphide, Electric Deportment of, VIII., 345.
Auriferous Alloys by Wet Processes, V., 370.
Awaruite—New Mineral, XVIII., 401.

Bismuth in Gold at the Owen River, XIX., 459; XX., 453.

Cause of the Deposition of Camphor towards Light, XII., 411.
Chromes, Artificial Preparation of, XXI., 359.
Crystalline Phosphates and Arseniates, II., 146.
Coprosma Bark tested for Alkaloids, II., 152.

Decomposition of Argentic Oxide by Mercury, XII., 414.
Desilvering Argentiferous Gold, I., 103; *n.e.* I., 47.
Dimorphism of Magnesia, XIII., 389.
Dr. Dudgeon's Experiments regarding the Temperature of the Breath, XIII., 437.

Electric Conductivity, New Forms of, XXIX., 581.
Electro-capillary Theory, Fallacy of, XXI., 363.
Electro-motive Power of Metallic Sulphides, III., 232.
" and Electrolytic Phenomena, IV., 313.
" Order of Metals, VIII., 334.
Examination of Manganese-ores for Cobalt, X., 448.
Existence of Hydro-carbons in Fats and Oils, XI., 527.

List of Chemical Papers contributed to other Publications by William Skey.

Report on New Zealand Flax. See Report on *Phormium tenax* (Hector), 1889, p. 47.

On the Absorption of Organic Matter from Solutions by Carbonaceous Substances, and the Formation thereby of Coal-seams. Proceedings of Royal Society, Edinburgh, 1866.

The following were printed in the London *Chemical News*:—

Formation of a Substance from Coal resembling Artificial Tannin.
On the Removal of Nitric Acid from Sulphuric Acid by Charcoal.
On some New Reactions of the Oxide of Tungsten.
Preliminary Notice of the Formation of certain New Ammonia Salts of the Metals, &c.
On a New Maroon Pigment.
On the Action of Alkalies upon Ferro- and Ferri-cyanides of Iron.
On a New Test for Cobalt in Solution.
Solubility of Cellulose in Ammoniated Copper.
Nature of the Gas escaping from Recently Prepared Charcoal on its Immersion in Water.
Volatility of the Compound of Sulpho-cynagen with Iron.
On the Production of some New Metallic Sulpho-cyanides. (Continuation of last paper.)
On the Property of Tungstic and Silicic Acids to combine with Phosphoric Acid, and the Presence of Phosphoric Acid in Opal and Flinty Quartz.
Solubility of Anhydrous Silica in Ammonia.
On the Coagulation and Precipitation of Clay by Neutral Salts generally.
On the Artificial Production of certain Crystalline Phosphates and Arsenates.
On the Formation of a Series of Double Sulpho-cyanides of certain of the Metals with the Alkaloids generally.
On the Effects of the Application of Hot Air to Blow-pipe Purposes, &c.
On the Alkalinity of Carbonate of Lime.
On the Absorptive Properties of Silica and its Direct Hydration by Water.
On the Examination of the Bark of the *Coprosma grandifolia* for Alkaloids.
On the Extraction of the Poisonous Principle of the Tutu Plant (*Coriaria ruscifolia*).
On the Fusibility of Platinum in the Blow-pipe Flame.
On the Application of Iodine and Bromine for the Detection of Gold in Small Quantities.
On the Absorption of Sulphur by Gold, and its Effects in retarding Amalgamation.
On the Production of a Mono-hydrate of Chloride of Barium (with Notes on its Crystallization, by E. H. Davis, F.G.S., F.C.S.).
Researches on the Absorptive Properties of Platinum.

On the Capability of certain Sulphides to form the Negative Pole of a Galvanic Circle.

On the Reduction of certain Metals from their Solutions by Metallic Sulphides, and the Relation of this to the Occurrence of Gold in the Native State.

On the Electro-motive Power of Metallic Sulphides.

On the Conducting-power of various Metallic Sulphides for Electricity.

On the Electro-motive and Electrolytic Phenomena developed by Gold and Platina in Solution of Alkaline Sulphides, &c.

On the Poisonous Principle of the Karaka.

Further Researches on the Precipitation of Clay from Clay Water.

On the Presence in certain Vegetable Fibres of a Substance susceptible of Well-marked Colouration by Chemical Treatment, and the Discrimination of such Fibres thereby.

On a New and Easy Process for generating Sulphuretted Hydrogen.

On the Absorption of Ammonia by Cellulose in Presence of Potash, and its Proposed Application to the Removal of it by this Method from certain Organic Solutions.

On a New Method for the Preparation of Sulpho-cyanide of Potassium for the Laboratory.

PROCEEDINGS

WELLINGTON PHILOSOPHICAL SOCIETY.

First Meeting: *25th June, 1901.*

Mr. G. V. Hudson, President, in the chair.

New Members.—Mr. Ben Keys, of Wellington; Rev. H. J. Fletcher, of Taupo; and Mr. D. Matheson, of Wellington.

Inaugural address by the President, G. V. Hudson, F.E.S., "On the Senses of Insects." (*Transactions*, p. 18.)

Sir James Hector spoke in high terms of the President's valuable and suggestive address. It took the thoughts of members out of the beaten track, and led them to the consideration of some of the profoundest and most suggestive problems of natural science. Regarding the external ears of the weta, he was reminded of somewhat similar organs found on the cephalic section of the Japanese crayfish—large and conspicuous auditory apparatus arranged like a Venetian-blind. Strange to say, the New Zealand species was quite destitute of these organs. He proposed a vote of thanks to the President for his instructive paper.

Mr. R. C. Harding seconded the motion. He said that bees were not, so far as he knew, supposed to be conspicuous for the homing instinct, a very small change in surroundings causing them to lose their way. He could not see that Lord Avebury's experiments justified the conclusion that light and colour appeared otherwise than as light and colour to all creatures with eyes, though it seemed to be proved that other creatures were sensitive to vast ranges of vibratory movements which made no impression on any of our senses. That colour produced similar effects on the nerves of vision of other creatures might be inferred, he thought, from the effects of the red rays. Lord Avebury had found them cause intense discomfort to insects; the irritating effect of red on birds and mammals was notorious in the instances of the turkey and the bull; and red in mass had an irritating effect on the human nervous system. If the weta was deaf to musical notes, such was not the case with all stridulating insects. He had on many occasions in warm weather noticed a cicada on the wall in church perfectly quiet and silent till the organ voluntary began, when the insect would keep up his characteristic note till the music had ceased, remaining quiet till the hymns were sung, and then joining in again. Others had doubtless observed the same in regard to this little insect.

Paper.—"On the Comet of 1901," by G. V. Hudson. (*Transactions*, p. 31.)

Some interesting exhibits of birds were shown by Sir James Hector, amongst which were two Rosella Parrots.

This gaily coloured bird is a native of Australia, but a few, escaped from captivity, have multiplied in the North Island. In New Zealand the bird is apparently taking to a ground life, with the result that a native variety far less adapted for flight than its Australian progenitor is already being developed.

Another curiosity was a sparrow with a deformed beak, the upper mandible being of extraordinary length and curved downwards, giving the head of the bird the appearance of that of a miniature female huia.

Second Meeting: *6th August, 1901.*

Mr. G. V. Hudson, President, in the chair.

Paper.— "On Caves in the Martinborough District, and Moa-bones found therein," by H. N. McLeod.

Abstract.

The paper set forth minutely the details of the route to the caves, which are situated on the Makara Stream (not to be confounded, of course, with the better-known Makara near Karori), as well as careful measurements of the caves and fissures and fossil bones found therein. The locality is about sixteen miles from Martinborough, and the caves are found in what is known as the "Cliff Paddock," a hill some 1,300 ft. high, with precipitous sides, rising from the stream. The stream itself appears to mark the route of a subterranean river. A stream issues from one of the caves, while in another place a creek plunges into a shaft and is lost to view. Moreover, after descending one of these pits, about 16 ft. deep, and winding along a narrow tunnel for some distance, the roar of an underground torrent was distinctly heard, but no access to the dark river was discovered. When the land was first occupied, some twenty years ago, the existence of the caves was unsuspected. The locality was covered by a forest so dense that, as the station-manager said, "a hawk could not have penetrated the undergrowth," yet from the various caverns since exposed quite a cartload of moa-bones, some of large size, have been removed, and are now mostly distributed among settlers in the neighbourhood. The author gave precise and minute descriptions of eight separate caves, also of the fossil remains, stalagmites, stalactites, and other ordinary contents of such receptacles. In the vertical shafts the bones of sheep and cattle were found, as well as those of extinct birds. The moa-bones had not only been found in the form of skeletons, but lying piled at the angles and in the narrow portions of the caves, where they had been carried by water. Investigations of a gallery, which they had some hope would open into a larger chamber, has been checked by stalactite pillars 12 in. to 18 in. in circumference. Water was still oozing from the roofs of the caverns, and the solid lime was still being slowly deposited. One passage, about 3 ft. wide, the sides coated with much siliceous deposit, somewhat damaging to clothing and knuckles, was followed up for quite 100 ft., when it became too narrow to permit of further progress.

Sir James Hector exhibited a map of New Zealand, especially prepared to show the distribution of moa remains, in which some hundreds of limestone caves in both Islands were indicated.

He said he remembered his own surprise in the early sixties, when first exploring such caves, at finding, as Mr. McLeod had done, bones of sheep and cattle mixed with fossils of a period generally supposed to be remote. The animals had fallen into the cave, and flowing water had carried the bones into strange company. The caves at Martinborough were geologically recent; others, notably at Takaka, in Nelson, were of far more ancient date. Hundreds of these caves had never been properly examined, and they were full of valuable material for the scientific investigator. He was glad that one of our members had devoted serious attention to the subject. Some of the secret caves of the Maoris in the North Island in particular would hereafter be mines of treasure for the archæologist. For ages the natives had been in the habit not only of depositing therein the bones of their great chiefs, priests, and warriors, but their most treasured heirlooms, in the way of greenstone ornaments, &c., which were practically imperishable, and were the sole remaining relics of native art of prehistoric times.

Sir James Hector exhibited the skeleton of a young female whale of a rare species—*Mesoplodon hectori*, Van Beneden —which, with its mother, was captured last March at Titahi Bay.

Only four specimens of this species had, he said, been met with. The first two were fragments only. The adult specimen on this occasion the Museum, unfortunately, had not been able to secure, and this was, therefore, the only perfect skeleton available. Strangely enough, the two other specimens had been found in the same little bay. The *Mesoplodon* might be regarded as a miniature species of the family of which the great sperm whale was the type. A northern species was known, differing in several points from the New Zealand species.

Sir James Hector directed the attention of the meeting to a collection of some forty or fifty out of a large collection of water-colour drawings of our native fishes by the late Mr. F. E. Clarke, a member of the Society.

He said Mr. Clarke's knowledge of fish was minute and accurate, and it would be difficult to exaggerate the beauty and scientific fidelity of his drawings. A special value attached to these drawings inasmuch as some represented rare and others absolutely unique specimens which had come under Mr. Clarke's observation—one of these, notably, a large shark of a kind which Sir James had never seen, and which was undescribed save by Mr. Clarke, while it differed remarkably from any other known species. At some distant day, perhaps, these valuable drawings might be reproduced and issued in book form—that was, if they could be secured for the Museum; as it was, they were in danger of being lost or dispersed. Mrs. Clarke was willing to dispose of them, and he hoped the collection would be purchased in its complete form by the colony.

The meeting expressed its concurrence.

Sir James, in continuing his remarks, said that something more than accurate delineation of our fishes was needed. We had still much to learn of their habits and life-history, though we knew far more about them than might be supposed from occasional reports published at public expense, in which, it was not too much to say, a great deal of nonsense might be found. One fact we could not escape—that New Zealand was an island, and that the surrounding hundred-fathom limit within which fishing operations could be conducted was a narrow one. It was impossible, in the absence of breeding-grounds such as the North Sea or the banks off Newfoundland, that New Zealand could ever establish a great fishing industry. He then called attention to some curious facts

about fishes, which, though no doubt familiar enough to naturalists, were not commonly known. The herring and the pilchard, he said, were so closely allied that the external resemblance might deceive an expert, yet they differed widely in their habits. The herring glued her ova to stone and seaweed at the bottom, where it hatched; but the pilchard discharged hers in the open water, to float to the surface and be hatched by the sun. The fishes themselves were so much alike that the usual test was to balance doubtful fish by the dorsal fin. If the head went up it was a pilchard, if the tail went up it was a herring. Pilchards were abundant off our coasts, but New Zealand had no herring. The flat fishes, he explained, started in life symmetrical and swimming upright, like other fishes. While still young they took to deeper waters, sunk, and lay at the bottom, turning to one side or the other. Deformation gradually set in, the upper side darkened, the eye underneath, being useless in its place, forced itself through the skull and came out on the upper side. A distinction between the sole and flounder tribe was that the sole lay with the left side and the flounder with the right side uppermost. A curious distinction between the English and New Zealand mackerel was that the southern fish was provided with a swim-bladder, which was absent in the English species. But the distinction was not a matter altogether of northern and southern distribution, for the only other mackerel besides that of New Zealand possessing the swim-bladder was found in the Black Sea.

A letter was received from Mr. J. T. Stewart calling attention to the fact that in boring in the Wanganui district for artesian water the water was obtained from below the papa rock. (*Transactions*, p. 451.)

Sir James Hector remarked that if this was the case it was a most important thing for the whole district.

Sir James Hector exhibited a preparation of the head and beak of a great octopus.

This was taken from a specimen captured at Island Bay, being the second specimen of the species found in that locality. The biggest of these could sweep into his ravenous maw any living creature within a circle a chain in diameter.

Specimens of some large Fiji chestnuts, about which very little is known, were exhibited.

Third Meeting: *5th November, 1901.*

Mr. G. V. Hudson, President, in the chair.

New Member.—Mr. T. L. Buick.

Mr. Martin Chapman was renominated to represent the Society on the Board of the New Zealand Institute.

A letter was read from the Secretary of the Canterbury Institute inviting members of the Wellington Philosophical Society to attend a garden party now being arranged to welcome the members of the British Antarctic expedition on their arrival in Lyttelton.

Mr. Hogben said that the expedition was expected about the last week of November.

The Chairman regretted that the Society would not have the opportunity of welcoming the party in Wellington also.

Volume XXXIII. of the Transactions was laid on the table.

Papers.—1. "Notes on *Coleoptera*," by Mr. J. H. Lewis. (*Transactions*, p. 201.)

The author explained that, with the exception of moths and butterflies, none of the orders of insects occurring in New Zealand could be considered to be catalogued in even a moderately satisfactory manner. The most extensive order, that of *Coleoptera*, was in almost as bad a state as any, for although much had been done and a long list of species published, yet the number of coleopterous insects occurring here was so great and the students so few that it would be many generations before all the forms were described. Description, though a dry and tedious process, was a needful preliminary to the elucidation of the problems connected with distribution and variation, which were the most attractive portions of the study of natural history. As in other orders so among beetles, the male insect was often different in form from the female. Not sufficient cognizance had been taken of this fact, except where the describer of a species had himself been able to study the insects in their homes, or where he had attached some weight to the observations of the field naturalist who had collected for him. Some results of this were evident in Captain Broun's list The frequent description of identical species in New Zealand and England would not cause so much trouble, as in most instances the identity was obvious. It was not for him to attempt to criticize the work of the able naturalist who had for a quarter of a century studied this order, but the reflection suggested itself that the larger genera might very well be tabulated by the only one who was at present in a position to do so. Was it too hazardous to say that when a table could not be prepared, then the species were not distinct? He had tabulated some families with much advantage to himself, but he was not anxious to publish his work while Captain Broun was able to do the same thing in a more accurate manner.

The President said that Mr. Lewis, who for the past ten years had been doing valuable work in his special department of entomology, was too modest in his claims, and he hoped that the results of his tabulations, so far as they had gone, would be published. There was a vast amount of this work to be done, and no naturalist could claim any prescriptive rights in the field of scientific research.

Professor Easterfield exhibited some branches of the whau (*Entelea arborescens*).

He said he had gathered these specimens from the bush on Sunday, in the only locality where the plant was known to exist between Wellington and New Plymouth, though it was found in localities on the East Coast, and was abundant north of Auckland. The specimen showed clusters of small pretty white flowers, also the seeds, rough and spiny, like large burrs of the piripiri. Mr. Mantell had a flowering-tree now growing in his garden, and at this moment was searching for a specimen. [As he spoke the specimen was brought in, displaying the bold green leaves and the flowers to great advantage.] He exhibited it because he thought it was little known, and was one of the most handsome of our many handsome shrubs, though the general form of the tree was not always graceful. In the bush it grew to a height of 30 ft. He understood that it was readily raised from seed. It was sometimes

known as "corkwood," on account of the exceptional lightness of the wood, which, because of this quality, was used by the natives for floats.

2. "Studies on the Chemistry of the New Zealand Flora: Part II., the Karaka-nut," by Professor Easterfield and Mr. B. C. Aston. (*Transactions*, p. 495.)

Twenty years ago, said Professor Easterfield, the late Mr. W. Skey, in the intervals of his official duties, pursued some investigations into this subject, and succeeded in isolating a white bitter substance, intensely poisonous, to which he gave the name "karakin." The quantity obtained was too minute to allow of thorough investigation, and Mr. Skey's results could therefore be accepted only as provisional. The melting-point of the substance was below 212° Fahr., or the heat of boiling water, and it was described as containing no nitrogen. He had begun the investigation *de novo*, and, though Mr. Skey had done excellent pioneer work, further investigation did not bear out all his conclusions. The karaka (*Corynocarpus*) was a tree well known throughout New Zealand. It was also found in some of the other islands of the Pacific, notably at the Chathams, where it was abundant, and on account of the absence of timber was an important tree—so much so that it was customary to inscribe symbols of ownership on the bark. A trunk in the Museum now had a mark of this kind, supposed to be a "portrait" of the former proprietor. The wood, however, was of little use as timber. One point he had been unable to ascertain, and he hoped that inquiries, if necessary, would be made and definite information obtained while a remnant of the Moriori people of the Chathams still survived—did they, like the Maori, prepare the kernel and use it as an article of food? The fruit of the karaka was a berry, the pulp of which some people esteemed. To him its taste was objectionable—suggestive of decayed dates. Within was a thin shell, enclosing a kernel possessing the qualities of a nut, and from which could be obtained a thick oil. [The oil, which was shown, was of a very dark-brown colour, and so thick as to appear almost solid, scarcely moving though the bottle was inverted.] This oil contained oleine and yielded oleic acid. The thickness of the oil was due to its association with vegetable wax. [The wax, pure white, was shown separately.] The poison did not reside in the oil, which was innocuous, had no bitter taste, and was just such as might be found in any of the sweet nuts. To prepare the kernels for food the Maoris first cooked the berries, which would have the effect of loosening the textures of the kernel and rendering it more accessible to the water in which it was afterwards soaked for a period varying from a few days to some weeks, when the poisonous constituents had disappeared. Mr. Skey, finding that the extract from the berries heated to boiling-point lost its bitter taste, inferred that the cooking was sufficient, without the subsequent process, to render the kernel non-poisonous. But he (the professor) found that if the nut was boiled in water prussic acid was given off. Now, only two other similar cases were known, and the only known substance yielding prussic acid by decomposition in this way was amygdaline, found in bitter almonds, peach and cherry kernels, &c. It seemed reasonable to infer that the karaka contained amygdaline or some analogous substance which by decomposition yielded prussic acid and a specific poison, while there was the alternative possibility that the poisonous effect of the kernel was due only to the prussic acid. There was another point of resemblance to the almond. From the original solution in water ether removed practically nothing, but if the solution was boiled and the prussic acid driven off then ether became effective as a solvent. Amygdaline isolated was not poisonous. It was found associated in the almond with a substance known as "emulsin," a kind of ferment closely allied to diastase, and to certain digestive ferments pro-

duced in the glands of animals. If a kernel containing these two substances was crushed in water, the action of the emulsin upon the amygdaline produced an immediate decomposition, prussic acid being formed. The natural ferment in the saliva produced a similar result on amygdaline, though in less degree. By numerous solutions and crystallizations he had isolated a white, bitter, poisonous substance, for which he had retained Mr. Skey's name of "karakin," though he could not absolutely say it was identical with Mr. Skey's product. For one thing, it contained a considerable proportion of nitrogen, and its melting-point was as high as 250° Fahr. If Mr. Skey's karakin was impure the lower melting-point would be accounted for, and there were two classes of substances that would resist Mr. Skey's test for nitrogen, this being one of them. In Mr. Skey's test he looked for the nitrogen to come off in the form of ammonia, whereas another reaction would take place and cyanide of sodium be formed. In addition to the karakin he had isolated another white crystalline substance, very similar in appearance, which he called "corynocarpin" [exhibited], with a higher melting-point than karakin. In addition to the wax he had found also mannite, a substance closely allied to sugar. Karakin he described as a glucoside—formula probably $C_{15}H_{24}N_3O_{15}$. It was interesting as the third example known in the vegetable kingdom of a substance which in its breaking-down yielded prussic acid, the first being the amygdaline of the almond and the second the *Lotus arabica*. Much still remained to be done in investigating the properties of karakin, as well as of the specific poison of the tutu. In the present case the amount of the sought-for glucoside amounted to 0·1 per cent. of the material tested, and there were fifteen crystallizations before a perfectly pure product could be obtained. The process was slow, laborious, and costly, and he was glad to say that the Royal Society had granted £50 towards the expense of the work on which he and his colleague were engaged.

3. "Raoult's Method for Molecular-weight Determination," by Professor Easterfield and James Bee. (*Transactions*, p. 497.)

These methods, the professor said, were practised in the laboratory of the Victoria College, and were easily within the reach of first-year students. They gave accurate results, and were performed in turn in the course of instruction by each member of the class. One of these methods, which was devised by himself, was to determine readily the densities of vapours at the actual boiling-point, a very difficult process by the usual methods—so difficult that densities were usually taken at a much higher temperature, leaving the density at the moment of vaporization uncertain. Already valuable results had been obtained with many substances, but so far his process had not been successful with mercury, in dealing with which special apparatus would be necessary. He thought, from his researches so far, that it might yet be demonstrated that the mercury atom consisted of two molecules.

The second part of the address was illustrated by an experiment in measuring and calculating molecular density by Mr. James Bee, of Wellington College, illustrating the simplicity and brevity of the method.

Two very large trout from Spring Creek, near Blenheim, belonging to Mr. T. E. Donne, and mounted by Mr. A. Yuill, taxidermist to the Museum, were on exhibition.

FOURTH MEETING: *11th February, 1902.*

Mr. G. V. Hudson, President, in the chair.

New Members.—Dr. Archer Hosking, of Masterton; Messrs. A. B. Chalmers, Gerald Fitzgerald, A. E. Pearce; and William Gray, of Palmerston North.

Papers.—1. "Embryology of New Zealand *Lepidoptera*," by Ambrose Quail, F.E.S. (*Transactions*, p. 226.)

2. "On a Marine *Galaxias* from the Auckland Islands," by Captain Hutton, F.R.S. (*Transactions*, p. 198.)

3. "On the Latent Heat of Fusion of the Elements and Compounds," by P. W. Robertson; communicated by Professor Easterfield. (*Transactions*, p. 501.)

Sir James Hector and Professor Easterfield spoke in high terms of the accuracy of Mr. Robertson's work, and of the great importance of his discovery. It would be known, the professor thought, as "Robertson's Law."

4. "On the Phenomena of Variation and their Symbolic Expression," by E. G. Brown. (*Transactions*, p. 520.)

Sir James Hector said that Mr. Brown was doing substantial and valuable work in one of the obscure corners of scientific research.

5. "On the Horizontal Component of the Earth's Motion in Space," by D. Hector; communicated by Sir J. Hector. (*Transactions*, p. 513.)

6. "Mathematical Treatment of the Problem of Production, Rent, Interest, and Wages," by D. Hector; communicated by Sir J. Hector. (*Transactions*, p. 514.)

7. Notes on New Zealand Fishes," by Sir J. Hector. (*Transactions*, p. 239.)

8. "The Vapour Densities of the Fatty Acids," by P. W. Robertson; communicated by Professor Easterfield. (*Transactions*, p. 499.)*

ANNUAL MEETING: *12th March, 1902.*

Mr. G. V. Hudson, President, in the chair.

ABSTRACT OF ANNUAL REPORT.

During the past year five meetings were held, at which twenty papers were read.

Nine new members have been added to the roll during the year, making a total of 147 members.

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* For discussion, see p. 570.

The balance-sheet shows the receipts for the year to be £156 10s 5d., and the expenditure £76 14s. 3d., leaving a balance in hand of £79 16s. 2d.

The Research Fund, a fixed deposit in the bank, now amounts to £36 10s. 10d., which increases the credit balance to £116 7s.

Election of Officers for 1902.—*President*—W. T. L. Travers, F.L.S.; *Vice-presidents*—Sir J. Hector, F.R.S., and R. L. Mestayer; *Council*—Messrs. H. N. McLeod, E. Tregear, F.G.S., M. Chapman, G. Hogben, M.A., R. C. Harding, G. V. Hudson, and Professor Easterfield; *Secretary and Treasurer*—R. B. Gore; *Auditor*—T. King.

Papers.—1. "The Theory of the Polar Planimeter," by C. E. Adams, B.Sc.

Sir James Hector said that a most ingenious form of a planimeter had been devised by Mr. Beverley, an inventive gentleman of Dunedin, still among us, and was shown at the New Zealand Exhibition nearly forty years ago. The following was an abstract of the account of Mr. Beverley's instrument which was given in the Report on the New Zealand Exhibition, 1865, page 188. This was now a very rare book. "Two Platometers (not named 'Planimeters'), invented and made by A. Beverley, Dunedin, are interesting and valuable instruments. An instrument to effect the same purpose was first exhibited by the famous inventor and mathematician Mr. E. Sang, of Kirkcaldy, in Scotland, at the exhibition of 1851. Other similar instruments have been invented, especially by Professor Clerk Maxwell, to overcome the mechanical difficulties by the introduction of contact spheres. This is a beautiful idea, but mechanically impossible. Mr. Beverley's platometer, which rejects sliding motion, and is very simple and inexpensive, should come into general use in all survey offices." At the same time he showed a clock which had been going ever since it was made without the aid of weights or springs—which, in fact, as far as motive-power was concerned, had been untouched since its construction. A glass cylinder filled with air resting on a surface of castor-oil supplied the power, every change in temperature affecting the pressure. The force thus generated was taken up by an ingenious mechanical contrivance and conveyed to the works. For forty years the timepiece had kept time without stopping, and it bade fair to go as long as the works held together and the day and night temperatures continued to vary.

A member who objected that the pinions would clog and wear out was reminded that the problem of perpetual motion was apart from wear-and-tear of mechanism.

Mr. Martin Chapman remarked that he had known the clock, which was still going, for many years past.

2. "Notes on the Sydney Chain Standard," by C. E. Adams, B.Sc.

Mr. Martin Chapman said that in order to be able to tell whether a thing was done properly its actual working had to be gone into. He once happened by accident to be concerned in a matter which enabled him to see how the testing of weights was worked practically. As members of the society probably knew, there were Inspectors of Weights and Measures all over the colony. These Inspectors were generally policemen. Sometimes they were retired policemen. An Inspector had a set of standard weights with which he had to compare weights submitted to him to be tested, or weights which were suspected to be untrue and which he had secured in order to test them. An important question, therefore, was how nearly the standard weights in the possession

of the Inspector agreed with the proper standard weights in the hands of the Government. Some time ago a circular was sent to certain persons in Wellington asking them to state the price at which they would furnish the Government with iron ingots. The respective weights required were specified, and it was also stated that the ingots had to have handles by which they could be lifted. One tender, sent in by a person of thoroughly good character, gave a price which amounted to a few pence per pound. His tender was at once accepted, with a condition, "Please let them be accurate." He replied that that was not exactly what he tendered for—that in the iron trade an inaccuracy of 4 or 5 per cent. in the weight of ingots was not thought to be worth considering, and that the ingots might be from a fraction of an ounce to several ounces out, according to their size. The conditions of contract were amended so as to require that the ingots should be accurate in weight, and a few pence per pound was added to the amount of the tender. The ingots were cast at a foundry, and they were weighed on the machine on which all metal arriving at the factory was weighed. They were passed by the gentleman who was appointed to pass them. The Government, however, then wrote to say that the "standard weights" which had been sent in had been found to be inaccurate. Previously they had used the word "ingots." These "standard weights" were accordingly adjusted, some by being planed down and others by being plastered up. And that was how the standard weights used by Inspectors were made. So it would be seen that an Act of Parliament might be perfect, and the standard weights obtained from England might be perfect, but if the manner in which the Act was worked was not perfect there would be inaccuracies as to weights and measures.

Mr. R. C. Harding said the weights in use in the post-offices apparently needed to be brought into uniformity, as he had known several cases where parcels which had been weighed and passed as correct in the office where they were posted had been surcharged and fined at the office of delivery.

3. "On the Vapour Densities of the Fatty Acids," by Professor Easterfield and P. W. Robertson. (*Transactions*, p. 499.) This paper, read at a previous meeting, was discussed.

Sir James Hector said the discovery was of great importance, and showed how admirably the professor was leading his students in original research. He deplored the lack of proper apparatus and appliances in the University for the prosecution of valuable work of this kind.

Mr. Tregear spoke of the hopeful prospects of the Philosophical Society. For years, as the pioneers fell out of the ranks, they had deplored the lack of younger men to fill the gaps. Now all this was changed. Young men of the greatest promise——

A Member: And young women too.

Mr. Tregear said, Yes, young women too—were taking a prominent place in the scientific field. He congratulated the professor and students on the energetic work—work of permanent value—they had already accomplished. We need have no fears as to the future of the Society.

4. "Natural-history Notes from Dusky Sound," by Richard Henry.

ABSTRACT.

1. *Pilchards.*—In reading back numbers of the Transactions I notice an account of the Picton herring which says that they remain in Queen Charlotte Sound all the year round, which implies that they must get their food there; and when they have no teeth their food must be small and soft; and when they flourish it implies that some

combination of circumstances relieves them from any very destructive enemies. I have seen pilchards in many places, and always wondered at their immense numbers and where they came from, for wherever I have seen them they seem to have thousands of enemies who could easily catch them. I dipped a baker's basket in the sea off Queenscliffe and got it half-full of pilchards, while the air was alive with birds and the water thick with porpoises and all sorts of fish following them. Surely they must have some peaceful places to breed in or they could not spare such losses without extinction. Cook Strait may be one of those. They represent the Home herring, and the herring is an old acquaintance of the salmon; therefore if the salmon have not been tried in Queen Charlotte Sound it might be a good plan to try some when you have the salmon, for they might meet with some favourable conditions that we do not understand. I have not seen pilchards on this southern coast, where we put most of the salmon, but Mr. Sutherland says that they come into Milford. It might also be a good plan to try a few salmon on this west coast if they never have been tried there, for there is great variety of conditions between such rivers as the Hollyford and those coming into the heads of the sounds. The temperature may be of great importance to give the young ones a start; and though there is a warm current coming down the coast the heads of the sounds are often frozen in winter. I think that owing to the quantity of food that sometimes comes in it is far the best coast for fish; but the rain brings a colouring matter out of the bush that darkens the water, and I think the fish do not like it, because it is only when the water clears that the shoals of migratory fish come in. However, this dark water is always much colder than the clear sea-water, and that may be why the fish dislike it.

2. *Vegetable Caterpillar.*—I exhibit an aweto or vegetable caterpillar in a tube. Sometimes live ones are plentiful here in the spring about the roots of the *Veronica* hedges, but they do not appear to grow fungi every year, for lately I cannot find one in that state, though the first years we were here they were plentiful, yet we saw no live ones. The one I exhibit is a fine big one, and was very lively when I got it, so I put it in the tube. I exhibit it now to show how fond it must be of growing fungi when it will grow it in a spirit-jar. When the fungus starts to grow in the ground it seems as if the caterpillar had laid itself out for it, for it often forms a cavity around its head as if to accommodate the fungus, and I would not wonder if they are friendly relations instead of enemies. If they ever do turn into moths it is curious that I have not seen any of them when I can see all the others so readily. I do not know what caterpillar the moth breeds from. I have tried to nurse the live caterpillars into moths, but they take so long that I have never succeeded. They have grown fungus several times, until I began to think that that was the destiny of all of them, but I cannot see how the fungus could lay caterpillars' eggs.

Sir James Hector remarked that the "Picton herring" spawned from twenty to thirty miles off the coast of New South Wales. It was a true pilchard; it was not a herring. There was no herring in these waters. It would be a valuable achievement if the herring could be introduced.

Mr. H. N. McLeod said he saw the fish in question at Picton a week ago. They were in such numbers that they made the water phosphorescent as far as the eye could reach.

Sir James Hector said the fish had put in an early appearance. There were no fish in these seas which deposited their eggs, as the herring did, at the bottom of the sea. The reason, he thought, was the absence of such natural banks as extended from England to Denmark, and the acclimatisation of the herring, desirable as it was, would probably on this account be a matter of great difficulty.

5. "Notes on the Entomology of New Zealand," by Captain J. J. Walker, of H.M S. "Ringarooma."

The President, in introducing Captain Walker, said that probably he had collected in more countries than any other entomologist.

ABSTRACT.

In the course of an interesting address Captain Walker commented on the way in which the indigenous flora had disappeared from the older settlements in New Zealand. It was astonishing, however, what a number of the original insects seemed to hold their own where a little native bush was left. When he was at Westport recently he was kept to his hotel for three days and a half by continuous rain. All that time, however, the Buller River was working for him by bringing beetles down from a hundred miles up-country. On going to the beach when the rain ceased he collected specimens of no fewer than 105 species of beetles. There was a prevalent idea in England that New Zealand was a very poor country for beetles. He considered, however, that it was on the average quite as rich in them as any country in corresponding latitudes, north or south, though possibly not so rich as Australia or Tasmania. There were fully as many species of *Coleoptera* in New Zealand as there were in the British Isles. The South Island was far better from a collector's point of view than the North. At first sight the statement that New Zealand was a poor country for beetles seemed to be quite true. Save for members of certain species, a person might go all day and see only a few beetles. Most of the beetles had to be rooted and worried out. If patient and persistent, a collector could be sure of getting his bottle full. The beach collecting in New Zealand was very interesting, and Lyall Bay, near Wellington, was a good ground. He had been only five months in New Zealand, and he had secured specimens of all the important coast beetles save one, and that he hoped to get every time he went to Lyall Bay. The fauna of New Zealand was most interesting, not only on account of what was represented in it, but because of what was not represented. It embraced the most curious and most beautiful collection of weevils in the world. The weevils of New Zealand ran into most bizarre and striking forms.

Mr. R. C. Harding and Sir James Hector spoke of the intimate knowledge of his subject which Captain Walker had displayed in his impromptu talk.

AUCKLAND INSTITUTE.

First Meeting: *3rd June, 1901.*

Mr. James Stewart, C.E., President, in the chair.

New Members.—J. Burns, M. Casey, Dr. H. H. Cheeseman, M. A. Clark, Dr. W. H. Goldie, J. Howden, H. W. Hudson, Mrs. E. A. Mackechnie, E. K. Mulgan, O. R. Nicholson, C. Macculloch, D. B. McDonald, W. J. Parker, W. J. Speigt, H. C. Tewsley, A. A. Wrigg.

The President delivered the anniversary address. (*Transactions*, p. 1.)

Second Meeting: *24th June, 1901.*

Mr. James Stewart, C.E., President, in the chair.

Mr. F. G. Ewington delivered a popular lecture entitled 'Brain *versus* Muscle in the Production of Wealth."

Third Meeting: *22nd July, 1901.*

Mr. James Stewart, C.E., President, in the chair.

Professor F. D. Brown gave a popular lecture, illustrated by numerous experiments, on "The Measurement of Time."

Fourth Meeting: *5th August, 1901.*

Mr. James Stewart, C.E., President, in the chair.

New Members.—J. J. Craig, W. Crosher, F. Mander, M. McLean.

The President said he had pleasure in announcing that the Institute had purchased for the Auckland Museum the celebrated Maori carved house formerly standing at Taheke, on the north side of Lake Rotoiti.

After some general remarks, he said that the history of the house, as far as particulars had been obtained, was as follows: In 1867, at which time several notable houses were being erected in the East Coast districts, it was suggested by Captain G. Mair and Mr. H. T. Clarke that one should be built at Taheke, near which a considerable number of

Maoris were then living. The proposal was taken up by the Maoris with very great enthusiasm. The carving was undertaken by Wero, Anaha te Rahui, and others of the Ngatitarawhai Tribe, with several well-known carvers of the Ngatipikiao Tribe. A large sum of money was collected from the neighbouring Maoris, many who were then employed by the Government as militia contributing a fixed proportion of their regular pay. The carving occupied between three and four years, and many of the side slabs were carved from the sides of famous old war-canoes which had been in the possession of the Maoris for generations, and which had been used against the Tohourangi at Te Ariki, and which had been dragged overland into Tarawera Lake. The house was completed about 1871. The principal owner was Te Waata Taranui, elder brother of the late Pokiha Taranui (Major Fox). It was named Rangitihi, after the well-known hero of that name, who, next to Tama-te-Kapua, was the most renowned ancestor of the Arawas. The house was nearly 60 ft. long by 25 ft. wide, and had a height of about 18 ft. to the crown of the roof. In 1882 Te Waata died, and was buried within the veranda, or porch, of the house. An elaborately carved tomb, in true Maori style, was put up over the grave. This was subsequently acquired by Sir Walter Buller, and, after being exhibited at the Indian and Colonial Exhibition, was finally presented to the Trocadero, at Paris. During the eruption of Tarawera the roof of the house was broken in by the vast quantity of mud lodged upon it. The house was consequently taken down and removed to Maketu, with the intention of re-erecting it there, a project which, for want of funds, was never carried out.

Papers.—1. "Descriptions of New Native Plants," by D. Petrie. (*Transactions*, p. 390.)

2. "On the Volcanic Ash-beds of the Auckland Isthmus," by E. K. Mulgan. (*Transactions*, p. 414.)

Fifth Meeting: *19th August, 1901.*

Mr. James Stewart, C.E., President, in the chair.

Professor H. A. Talbot-Tubbs gave a popular lecture, illustrated with numerous limelight illustrations, on "Greek Painted Vases: their Importance, Form, and Design."

Sixth Meeting: *2nd September, 1901.*

Mr. James Stewart, C.E., President, in the chair.

New Member.—A. D. Austin, F.R.A.S.

Papers.—1. "On the Recent Statistics of Insanity, Cancer, and Phthisis," by Professor H. A. Segar. (*Transactions*, p. 115.)

2. "On the Flora of the District between the Manukau and Waikato," by H. Carse. (*Transactions*, p. 362.)

3. "Exhibition of Astronomical Photographs," by A. D. Austin, F.R.A.S.

Seventh Meeting: *23rd September, 1901.*

Mr. James Stewart, C.E., President, in the chair.

Mr. E. V. Miller delivered a popular lecture entitled "Ruskin's Influence on Economic Science."

Eighth Meeting: *7th October, 1901.*

Mr. James Stewart, C.E., President, in the chair.

New Members.—A. S. Bankart, S. Gray.

Papers.—1. "On Maori Games," by Elsdon Best. (*Transactions*, p. 34.)

2. "On Maori Magic," by Elsdon Best. (*Transactions*, p. 69.)

3. "On the Growth of Indigenous Trees," by H. D. M. Haszard. (*Transactions*, p. 386.)

4. "Remarks on Indigenous Trees planted at Parawai, Thames, in 1873 and subsequently," by J. W. Hall. (*Transactions*, p. 388.)

5. "On the Occurrence of *Panax arboreum* as an Epiphyte on the Stems of Tree Ferns in the Mauku District," by H. Carse. (*Transactions*, p. 359.)

6. "On the Mollusca of Little Barrier Island," by H. Suter. (*Transactions*, p. 204.)

7. "List of the Species described in F. W. Hutton's Manual of the New Zealand Mollusca, with the Corresponding Names used at the Present Time," by H. Suter. (*Transactions*, p. 207.)

Ninth Meeting: *28th October, 1901.*

Mr. James Stewart, C.E., President, in the chair.

Professor A. P. W. Thomas gave a popular lecture, illustrated with numerous limelight illustrations, entitled "Across the Mountains."

Annual Meeting: *24th February, 1902.*

Mr. James Stewart, C.E., President, in the chair.

New Members.—J. H. Howell, A. M. Myers, A. Waterworth.

ABSTRACT OF ANNUAL REPORT.

The Council submits the thirty-fourth annual report, dealing with the financial and general condition of the Institute and the progress it has made during the past year.

Twenty-four new members have been elected during the year, a number considerably above the average. On the other hand, seventeen names have been withdrawn from the roll—five from death, six from resignation, and six from non-payment of subscription for more than two consecutive years. The nett gain is thus seven, the number on the roll at the present time being 162. The members removed by death are Mr. W. Aitken, Captain Colbeck, Mr. E. T. Dufaur, Mr. S. Eastham, and Mr. W. Hill, all of whom have been associated with the Institute for many years.

The balance-sheets accompanying the report give full particulars of the financial position of the Institute, so that a brief synopsis is all that need be given here. Omitting the donations received for the purchase of the Mair collection, which will be referred to in a special paragraph, and also excluding the balance of £136 1s. 6d. in hand at the commencement of the year, the total revenue of the working account has been £759 8s. 10d., as against £897 7s. 4d. for the previous year. The interest yielded by the invested funds of the Costley Bequest has been £365 8s. 2d., the amount for 1900–1901 being £436 5s. The Museum Endowment has contributed in rents and interest £309 10s., the sum for the previous year being £333 11s. 7d. The members' subscriptions have amounted to £126, showing a substantial increase on the sum collected during the last year. The total expenditure, omitting the amount paid for the Mair collection and the Maori house, has been £869 3s. 10d., leaving a credit balance of £76 6s. 6d. in the Bank of New Zealand. The Council are glad to report that the invested funds of the Institute are in a satisfactory state. The total amount at the present time is £13,877 8s. 9d., showing an increase of £287 18s. 9d. during the year. With the exception of a few hundred pounds lodged in the Bank of New Zealand, the whole of this is invested in mortgage on freehold properties or in Government debentures.

The Crown Lands Board have sold two small blocks of country lands during the year, and the proceeds, amounting to £413 12s., have been paid over to the Institute for the purpose of investment. With this exception, there is little to report under this head. The interest on the capital sum invested has been regularly received, and the Crown Lands Board has from time to time handed over the rents derived from those endowments which are leased. The Council regrets that there are several endowments situated in country townships which are apparently unsaleable at present, and from which no revenue is being obtained.

Nine meetings have been held during the year, at which eighteen papers were read.

The most noteworthy occurrence in connection with the Museum is undoubtedly the purchase of the Mair Maori collection. This, which was deposited in the Museum by Captain Gilbert Mair in 1890, has long been admitted to be the best private collection of the kind in existence, and its removal would have done irreparable harm to the Museum. When Captain Mair intimated in September last that he intended to dispose of the collection, and that offers had already been made for it by several European museums, the Council at once recognised that an effort must be made to retain it in Auckland. The price asked was £1,000, which was to cover not only the articles in the Museum, but a considerable number of others which had been retained by Captain Mair in his own possession, the total number of specimens being about four hundred. The Council need hardly say that the Institute itself was unable to make the purchase. For many years the whole of the revenue

has been absorbed by the growing needs of the Museum, and to have drawn so large a sum as £1,000 from the invested capital, upon which the income of the society depends, would have been rash and injudicious in the extreme. Under such circumstances, it was decided to issue a circular to the citizens of Auckland, explaining the position and inviting donations for the purchase of the collection as the only means of retaining it in Auckland. The response to this invitation has been most generous, and has amply proved that the people of Auckland are ready and willing to support any object of undoubted public utility. The amount contributed up to the present time has been £962 7s. 7d., and there can be little doubt that the full sum of £1,000 will be obtained before the subscription-lists are finally closed. In the meantime the collection has been secured, and the whole of it is now displayed in the Museum. The Council has great pleasure in recording their most grateful thanks for the liberal and sympathetic assistance which has been so freely rendered. A full list of all donors will be found appended to the report.

The Council has also to report the purchase of the well-known Maori carved house Te Rangitihi, formerly standing at Taheke, on the northern shore of Lake Rotoiti. This house, which is about 60 ft. in length by 25 ft. in width, with a height of 18 ft., is beautifully carved throughout, and is considered to be one of the best and most complete *runanga* houses in existence, and will doubtless form a most attractive addition to the Museum. It is hoped to erect it as an annexe to the eastern side of the Maori hall, but the estimated cost is so large that it is doubtful whether it is within the means of the Institute. The matter is now in the hands of a sub-committee, which will report to the Council. The thanks of the Institute are due to Captain G. Mair for his assistance in negotiating the purchase.

The Institute still retains the management of Little Barrier Island as a reserve for the preservation of the avifauna of New Zealand. The curator, Mr. Shakespear, has resided on the island during the year, and reports that no unauthorised persons have landed thereon, and that no attempt has been made to interfere with the birds. So far as can be ascertained, the birds show no signs of decreasing in numbers; in fact, the curator is of opinion that several species have shown a decided increase during the last two or three years. There can be little doubt that if a resident guardian is maintained on the island it will for many years remain a secure home for a large part of the avifauna of New Zealand.

Election of Officers for 1902.—*President*—E. Roberton, M.D.; *Vice-presidents*—J. Stewart, M.I.C.E., and Professor H. W. Segar; *Council*—Professor F. D. Brown, C. Cooper, H. Haines, F.R.C.S., E. V. Miller, T. Peacock, D. Petrie, J. A. Pond, H. Swale, M.D., Professor H. A. Talbot-Tubbs, Professor A. P. W. Thomas, F.L.S., and J. H. Upton; *Secretary and Curator*—T. F. Cheeseman, F.L.S., F.Z.S.

Paper.—"On the Volcanic Belts of the Auckland Isthmus," by C. E. Fox. (*Transactions*, p. 452.)

PHILOSOPHICAL INSTITUTE OF CANTERBURY.

FIRST MEETING: *1st May, 1901.*

Captain F. W. Hutton, President, in the chair.

New Member.—Miss N. A. Greensill.

Address.—Professor Dendy delivered an address on "Some Conditions of Progress."

SECOND MEETING: *5th June, 1901.*

Captain F. W. Hutton, President, in the chair.

New Members.—Rev. R. T. Mathews, Miss M. F. Olliver, M.A.

Address.—Mr. L. Cockayne delivered an address on "The Chatham Islands."

The address was illustrated by a large series of lantern-slides from photographs taken by the lecturer to illustrate the characteristics of the vegetation of the islands, and by specimens of Moriori carving and other exhibits.

THIRD MEETING: *3rd July, 1901.*

Captain F. W. Hutton, President, in the chair.

New Members.—Rev. J. Campbell, Mr. A. T. Pycroft.

Papers.—1. "On the Occurrence of *Alepisaurus ferox* on the Coast of New Zealand," by Captain F. W. Hutton. (*Transactions*, p. 197.)

2. "On a Small Collection of *Diptera* from the Southern Islands of New Zealand," by Captain F. W. Hutton. (*Transactions*, p. 169.)

Dr. Chilton explained the action taken by the Council to promote the publication of an "Index Faunæ Novæ-Zealandiæ"—*i.e.*, a list of all species of animals recorded from New Zealand, with at least one reference for each species.

A petition prepared, asking the Governors of the New Zealand Institute to undertake the publication of the index, was laid on the table for signature.

Captain F. W. Hutton exhibited specimens of graptolites from Preservation Inlet.

Dr. Chilton exhibited specimens of a fresh-water shrimp, *Xiphocaris compressa*, de Haan, from Norfolk Island.

FOURTH MEETING: *7th August, 1901.*

Captain F. W. Hutton, President, in the chair.

Address.—Professor Dendy delivered an address on "The Sense of Sight," illustrated by numerous diagrams.

Dr. Chilton exhibited specimens of Schizopod Crustaceans (*Euphansia* and *Nyctiphanes* spp.) found at Sumner by Dr. Dendy, and made remarks upon their luminiferous organs.

FIFTH MEETING: *5th September, 1901.*

Mr. J. B. Mayne, Vice-president, in the chair.

Address.— Professor Arnold Wall, M.A., delivered an address on "Evolution in Literary Types," and a discussion followed in which several of those present took part.

SIXTH MEETING: *2nd October, 1901.*

Captain F. W. Hutton, President, in the chair.

Address.—Dr. Charles Chilton delivered an address on "Learned Societies of Europe."

Paper.—"Relics of the Moriori Race," by Professor Arthur Dendy. (*Transactions*, p. 123.)

SEVENTH MEETING: *6th November, 1901.*

Captain F. W. Hutton, President, in the chair.

Professor Dendy exhibited and made remarks upon a new type of pelagic hydroid recently obtained at Sumner.

Papers.—1. "The Beetles of the Auckland Islands," by Captain F. W. Hutton. (*Transactions*, p. 175.)

2. "Additions to the *Diptera* Fauna of New Zealand," by Captain F. W. Hutton. (*Transactions*, p. 179.)

3. "On a New Fossil *Pecten* from the Chatham Islands," by Captain F. W. Hutton. (*Transactions*, p. 196.)

4. "Revised List of New Zealand Seaweeds, Part II.," by R. M. Laing, M.A. (*Transactions*, p. 327.)

5. "A Short Account of the Plant-covering of Chatham Island," by L. Cockayne. (*Transactions*, p. 243.)

6. "Notes on the New Zealand Lamprey," by Professor Dendy and Miss M. F. Olliver, M.A. (*Transactions*, p. 147.)

7. "Notes on the Breeding Habits of the Tuatara," by James Ashley; communicated by Professor Dendy.

ABSTRACT.

From some old notes I have recently come on I see I got a pair of tuataras on the 10th November, 1892. I kept them in a large cage, and noted that the female laid the following eggs: One on the 21st December, 1892, six on the 22nd, one on the 23rd, one on the 25th, and one on the 29th; total, ten. Not knowing anything of their habits, I took the eggs, which were about the size of pigeons' eggs, and with soft shells, and placed them in cotton wool in a window of my little workshop facing the sun. Some days afterwards I missed one, and later on another, so, thinking the children were taking them, I locked the place up, yet they went till I had none left. By this time, or at least whilst any were left, I noticed they had shrivelled up considerably. I then examined the nest and found unmistakable evidence of how they were going—viz., mice. I was sorry I could not hatch them, but probably I could not have done so in any case.

8. "Mites attacking Beetles and Moths," by W. W. Smith. (*Transactions*, p. 199.)

9. "On a New Zealand *Isotachis* new to Science," by E. S. Salmon; communicated by Robert Brown. (*Transactions*, p. 325.)

ANNUAL MEETING: *2nd April, 1902.*

Dr. W. P. Evans, Vice-president, in the chair.

New Member.—Miss Low.

ABSTRACT OF ANNUAL REPORT.

Since the last annual meeting seven ordinary meetings have been held, at which twelve papers have been read. These papers may be classified as follows: Zoology, 7; botany, 3; geology, 1; anthropology, 1.

At several of the meetings addresses of more popular interest were delivered—viz., "Some Conditions of Progress," by Professor Arthur Dendy; "The Chatham Islands," by Mr. L. Cockayne; "The Sense of Sight," by Professor Dendy; "Evolution in Literary Types," by Professor Arnold Wall; "Learned Societies of Europe," by Dr. Charles Chilton.

The attendance at the ordinary meetings has averaged 26.

The Council of the Institute has met eight times since the last annual meeting. During the year the Council drew up a petition urging upon the Governors of the New Zealand Institute the desirability of

publishing an "Index Faunæ Novæ-Zealandiæ," containing a list of all species of animals recorded from New Zealand, with at least one reference for each species, and suggesting that the index should be edited by Captain F. W. Hutton, who has already published numerous catalogues of the different zoological groups, and has a large amount of manuscripts, suitable for the index, already prepared. Copies of the petition were sent to the other Affiliated Societies, and were returned, numerously signed, by the Otago Institute and the Hawke's Bay Philosophical Institute. These, together with the petition from this Institute, were forwarded to the Governors of the New Zealand Institute. In due time a reply was received stating that the Governors had given the matter careful consideration, but, whilst appreciating the value and practical importance of such a work when complete, they "considered that its production at the present time would be premature, more particularly as the classification and nomenclature of the indigenous faunæ of New Zealand is at present undergoing active critical discussion by experts in Europe and America."

During the year many books and periodicals have been bound. Besides the books added by purchase and by exchanges, a valuable donation, consisting of a set of the *Journal of the Royal Microscopical Society*, nearly complete, was received from the widow of the late Mr. H. R. Webb. A rearrangement has been made by which the various periodicals are now received direct from Messrs. Dulan and Co., of London.

Before the arrival of the Antarctic Exploration Expedition the Council urged upon the local authorities the desirability of welcoming and entertaining the members of the expedition. On their arrival in Lyttelton the members of the expedition were met and welcomed by the President and members of the Council, and during their stay they were entertained at a public dinner given conjointly by the Institute and the citizens of Christchurch.

The Hon. C. C. Bowen continues to represent the Institute on the Board of Governors of the New Zealand Institute, and the Council wishes to express the indebtedness of the Institute to him for his services. Thanks are also due to Mr. George Way, F.I.A.N.Z., for his valuable services as honorary auditor.

The total number of members of the Institute is now sixty-nine.

The balance-sheet shows that the subscriptions received amount to £66 13s.; £21 3s. 4d. has been spent on books and £16 18s. 3d. on printing and binding, and a new book-case has been added to the library at a cost of £10 5s. The balance in the bank to the credit of the Institute on the 31st December, 1901, was £29 15s. 8d., and the invested funds arising from life-members' subscriptions now amount to £79 10s. 6d.

Election of Officers for 1902.—*President*—J. B. Mayne, B.A.; *Vice-presidents*—C. C. Farr and A. E. Flower; *Hon. Secretary and Treasurer*—Dr. Charles Chilton; *Council*—Captain F. W. Hutton, Dr. W. P. Evans, R. M. Laing, L. Cockayne, R. Nairn, and Miss Olliver; *Hon. Auditor*—George Way, F.I.A.N.Z.

The address by the retiring President (Captain F. W. Hutton), on "Penguins and Petrels," was postponed till next meeting.

OTAGO INSTITUTE.

FIRST MEETING: *14th May, 1901.*

Mr. G. M. Thomson, F.L.S., President, in the chair.

Amended rules consistent with the practice of the Institute were submitted to the meeting and adopted without discussion, and, on the motion of Mr. F. R. Chapman, it was resolved, "That the Institute proceed to incorporate under the Unclassified Societies Act."

New Members.—Professor Park, Dr. Marshall, and Messrs. D. B. Waters, D. E. Theomin, E. R. Smith, and W. H. Smith.

The Chairman reported the progress that had been made in the direction of the establishment of a fish-hatchery.

The Government department had, he said, met them very fairly in the way of facilitating progress. A site had been selected opposite Portobello, and steps had been taken towards acquiring the necessary land. When this was done he presumed the Government would take steps to incorporate a small working body to carry on the station.

Mr. F. R. Chapman exhibited a very valuable collection of stone implements from different parts of the world, including, for the sake of comparison, some New Zealand examples.

The most notable of the exhibits were three from Sweden belonging to the Neolithic age. There were also some recent ones from New Guinea, one of which was remarkably symmetrical and was finished with the greatest care. Amongst other things, comparison was made between a jade implement from New Guinea and some polished stone implements of different size but similar make from Italy. The explanatory remarks proved most interesting, and were applauded. One of the specimens from Italy, Mr. Chapman remarked, was most probably fully ten thousand years old, and yet it was as well preserved as if it had been made within the last twenty years.

Dr. Colquhoun delivered an address, giving an account of recent researches in "The Relations of Mosquitoes to Malarial Fever."

ABSTRACT.

The subject was a technical one, but it was dealt with in a manner which made it clear and interesting to all, the history and results of the researches made by men of science in Italy, France, India, and England being mentioned. The subject of malaria, the speaker said, was, fortunately for the people of New Zealand, merely of academical interest, though throughout the British Empire malarial fever was second only to tuberculosis in its ravages. It was very prevalent and largely fatal in India, and it was quite impossible to state the number who were attacked by and died of this fever in Africa. In Italy whole

districts had been depopulated by it, and the same thing had occurred in America. The subject was one of immense importance to the world, and particularly to our Empire. Some of the guesses in the past regarding the cause of this disease had been singularly near the truth, and modern scientific research had proved up to the hilt that the mosquito grew the germ in its own tissues, carried it to human beings, and infected them with the disease. It was not every kind of mosquito that did this, but only *Anopheles*. Investigations showed clearly that this was actually the case, and it had been thought possible to stop the disease by destroying the mosquitoes. Some good had been done in this way by draining swamps and otherwise destroying the insects, but it was found that they were not easily dealt with. The speaker explained his subject by means of some very fine diagrams, and also exhibited a number of books and periodicals containing accounts of scientific research into this subject.

A short discussion took place, and a hearty vote of thanks was passed to Dr. Colquhoun for the clear and highly interesting manner in which he had dealt with the subject.

Second Meeting: *11th June, 1901.*

Mr. G. M. Thomson, President, in the chair.

The President communicated to the Institute a letter from Mr. Morton, local secretary at Hobart for the Australasian Association for the Advancement of Science, giving some account of the programme of the meeting to be held in January, 1902.

The President laid before the Institute a scheme for compiling a faunal census for New Zealand in collaboration with the other Affiliated Societies.

Papers.—1. "An Account of the External Anatomy of a Baby Rorqual (*Balænoptera rostrata*)," by W. Blaxland Benham, D.Sc., M.A., F.Z.S. (*Transactions*, p. 151.)

2. "Note on an Entire Egg of a Moa now in the Museum of the University of Otago," by W. B. Benham, D.Sc., M.A., F.Z.S. (*Transactions*, p. 149.)

3. "On Charity Organization," by Miss K. Browning.

This paper gave an account of the aims and methods of the Charity Organization Society from her own experiences as a volunteer helper.

The paper was followed by some discussion.

Third Meeting: *9th July, 1901.*

Mr. G. M. Thomson, President, in the chair.

New Members.—Rev. Canon Mayne, Miss Rees, and Miss Lena Stewart.

A letter was received from the Philosophical Institute of Canterbury enclosing a petition for presentation to the Board

of Governors of the New Zealand Institute, requesting the New Zealand Institute to undertake the publication of an "Index Faunæ Novæ-Zealandiæ," a catalogue, with references, of all the species of animals hitherto described from the New Zealand area.

In order to secure uniformity, it was proposed that Captain Hutton, F.R.S., Curator of the Canterbury Museum, be requested to act as editor.

The Chairman expressed the hope that all the members present would sign the petition. He said that the preparation of the work presented no difficulty, provided that the Government, through the New Zealand Institute, would undertake its publication.

Paper.—"The Beginnings of Literature in New Zealand: Part II., the English Section—Newspapers," by Dr. T. M. Hocken, F.L.S. (*Transactions*, p. 99.)

Prior to delivering his lecture he called attention to a number of interesting exhibits of early New Zealand newspapers, including copies of the *New Zealand Gazette* (Wellington), the first newspaper ever printed in the colony, dated April, 1840; the curious old newspaper printed on blotting-paper; the ancient and famous Auckland paper printed on a mangle; and the early Bay of Islands papers, which were wretchedly printed. Dr. Hocken adverted to the fact that last year he had placed a paper before the Institute dealing with the Maori section of literature, but he would now deal with the purely English section of his subject as it struggled into life. Starting with the publication of the first newspaper, Dr. Hocken traced in an intensely interesting fashion the rise and fall of the multifarious newspaper ventures characteristic of pioneer times, the recital of which was enlivened with many personal reminiscences of men and things, and humorous incidents of the struggles and difficulties of this early day journalism. Taking the several newspapers, and dealing with them according to locality rather than date, the lecturer described the beginnings and endings of the first Wellington papers, which, after all sorts of vicissitudes, were incorporated with the present *New Zealand Times*. The Bay of Islands prints were then briefly alluded to, four of them having an average life of ten months each. The Auckland journals came next in order, and the historic newspapers that formed the connecting-link between ancient and modern journalism, finally culminating in the *Auckland Herald*, made matter for amusing and instructive description. The *Nelson Examiner* and *New Zealand Chronicle* were the last under review.

The Chairman said that he trusted that Dr. Hocken's health would be so far renewed by his proposed trip that he would be enabled to complete the valuable work of which that evening's lecture was only one chapter. It would prove of untold value as a contribution to the history of the colony, and he knew of no one better fitted to undertake and carry through the task than Dr. Hocken. The amount of research involved was no inconsiderable item. In listening to the lecture he had been impressed with the surprising vitality and exuberance displayed by the writers in these early journalistic ventures, in which respect history certainly was repeating itself.

Mr. F. R. Chapman, in congratulating Dr. Hocken upon his paper, said that they were drawing near to the end of the time when it would be possible to obtain accurate information concerning the early history of the colony and of its provinces.

Fourth Meeting: *13th August, 1901.*

Mr. G. M. Thomson, President, in the chair.

New Member.—Dr. Young, of Invercargill.

Dr. Benham, curator of the Museum, took the opportunity to bring under the notice of members a few specimens recently added to the Museum.

The first was a specimen of the squid, occasionally cast ashore in the harbour. Another was the New Zealand cockchafer (*Prionoplus reticularis*), mounted to show its life-history from its early stages till it becomes the full-grown beetle. Specimens of *Phalangium chelifer-oides*, *Mantis*, and weta, mounted in alcohol, were exhibited, and then two specimens of the leaf insect. One of these was from Fiji, and the other had been sent to the Museum by Mr. Goyen, who got it from a man in the Catlin's district. Dr. Benham said it was not a native of these islands. After exhibiting two scorpions from India, he then showed a couple of lizards, one of a common variety found on the Peninsula, and another which appeared to be new to science. It was found at Fortrose by a man who thought it was a tuatara. Seeing an advertisement in a paper offering £1 for a tuatara, he brought it up to Dunedin. It was a beautifully coloured lizard, having brown, red, and green markings. He had not had time to work it out thoroughly, but as far as he could judge it was an entirely new variety. A couple of living specimens of *Paryphanta hochstetteri* from Pelorus Sound were also on view.

Dr. Colquhoun read a paper entitled "Tennyson and Science."

Fifth Meeting: *10th September, 1901.*

Mr. G. M. Thomson, President, in the chair.

An advance volume of the "Transactions of the New Zealand Institute" was laid on the table.

Mr. T. D. Pearce, M.A., read a paper on "Erasmus."

There were exhibited by Mr. C. Brown some fossil leaves from the Kaikorai Valley, and a fossil fish from the same beds, collected by Mr. S. Thomson.

Dr. P. Marshall made some remarks on the leaves, and Professor Benham identified the fish as a species of *Hemirhamphus*.

Sixth Meeting: *8th October, 1901.*

Mr. G. M. Thomson, President, in the chair.

Dr. P. Marshall delivered a highly interesting address on "Leaf-beds in the Kaikorai Valley," and laid on the table a paper which he had prepared on the subject.

The existence of leaf-beds in the neighbourhood of Dunedin, he said, had long been known, but their exact position seemed of late years to have been forgotten. After describing the geological formation of the

locality, which he placed in the Oligocene period, Dr. Marshall said that from a preliminary cursory examination he had been led to believe that all the leaves whose impressions are to be found in the bed would prove to belong to a species of plants still quite common in New Zealand, but a closer inspection showed that in nearly every case they were utterly different from the plants at present growing in New Zealand soil. For the most part, the leaves belonged apparently to a species of oak, elm, birch, or beech. There were several kinds of beech-trees here, but the fossil leaves differed more from those of the present New Zealand beech-trees than they did from the beech-trees of England, and they indicated a very close alliance with the flora of England. There were leaves also which represented the remains of *Magnolia*. The *Magnolia* was a plant which had entirely disappeared from the flora of Australia and New Zealand, and was now characteristic of North America and Asia. Two leaves certainly represented a species of rata very closely allied to the large rata of the North Island. It would be known, the speaker continued, by those who paid any attention to the classification of fossil flora that Baron Von Ettingshausen considered that in all parts of the globe the Eocene and early Tertiary flora contained an assemblage of species indicating a generalised flora. Towards the close of the Tertiary age he supposed that one section of the flora—the principal element—became dominant, while the other forms sunk to co-elements. He considered that climatic variations and changes must be held to account for the dominance of the principal element in any country. An exact determination of the flora in such a deposit as that of the Kaikorai Valley would enable one to judge of the nature of the climatic changes that in New Zealand had induced the dominance of such a peculiar "principal element" as now characterized our flora. So far as the present leaf-bed can be used in this connection, it appeared that, although the climate during the deposition of these leaf-beds was, on the whole, probably a little milder than the present climate, a subsequent increase in temperature took place, securing the preservation of such forms as *Piper* and *Metrosideros*, while the oaks, elms, beeches, &c., became extinct. It was to be hoped that a fuller description of the flora would be afterwards given, with, if it were deemed advisable, the greater definiteness that was gained from specific identifications and specific descriptions. At present it was interesting to note the presence of *Magnolia* and *Metrosideros* and *Piper* in our Tertiary flora.

Mr. Malcolm Thomson, M.A., read an account of a new species of Annelid (*Polynoe comma*) from New Zealand waters. (*Transactions*, p. 241.)

It lives as a commensal in the tube of a Terebellid.

Professor Benham read a paper on the "Osteology and other Parts of *Cogia breviceps*" (*Transactions*, p. 155), and exhibited a number of ethnological specimens from Malekula, New Hebrides, recently acquired by the Museum.

Annual Meeting: *12th November, 1901.*

Mr. G. M. Thomson, President, in the chair.

New Member.—Mr. George Howes, F.E.S.

On the motion of the Chairman, the following resolution was affirmed: "That the Otago Institute become registered under 'The Unclassified Societies Act, 1895.'"

Papers.—1. "Notes on some Glacier Moraines in the Leith Valley, Dunedin," by Professor Park. (*Transactions*, p. 444.)

2. "Notes on the Secular Movements of the New Zealand Coast-line," by Professor Park. (*Transactions*, p. 440.)

3. "Notes on the Thames Goldfields," by Professor Park. (*Transactions*, p. 435.)

4. "Reference List to the Literature of New Zealand Fishes," by Mr. A. Hamilton. (*Transactions*, p. 539.)

5. "Notice of an Electric Ray new to the Fauna of New Zealand, belonging to the Genus *Astrape*," by Mr. A. Hamilton. (*Transactions*, p. 224.)

6. "On the Method of Feeding by the Rorqual," by R. Henry.

A fine specimen of *Histopterus*, or boar-fish, caught off Napier in 1900, was exhibited.

A specimen of the brilliantly coloured fish "Opha" (*Lampris lima*) was recently caught off Timaru and exhibited in Dunedin, but was acquired for an Australian museum.

Abstract of Annual Report.

The Council have held seven meetings for the transaction of the business of the Institute. During the session the Council have been deprived of the services of two of their number—viz., Mr. Melland, who went to England in July, and Dr. Hocken, who left Dunedin in August for a trip to Europe. Your Council did not deem it necessary to make use of their powers to fill these vacancies.

The usual number of meetings of the members has been held, and the plan adopted last year of arranging a definite programme of lectures has been again followed; yet the Council still have reason to regret the relatively small number of members that have been attracted by these lectures, which have covered a wide range of subjects. In addition to these lectures, eleven original contributions have been laid before the Institute for publication in the Transactions. A few years ago it was suggested that natural-history notes—records of observations scarcely worthy of being termed "papers"—might be made by members and handed to the secretary from time to time, but hitherto no response has been made. To the naturalist every careful and accurate observation, however slight and apparently unimportant, has its value, and the Council would welcome the notes, whether made by the wayside, or the sea-side, or in the bush. Our native fauna and flora are rapidly disappearing, so that every opportunity should be taken of putting on record any observation of habits, of occurrence, of species, &c.

The number of new members elected during the session is eleven, and the Council hope that this is a promise of further increase, and that some of these new members will, by their efforts, contribute towards rendering the meetings interesting and varied.

During the last few years, owing to insufficiency of funds, it has been impossible to carry out the binding of the periodicals, but during the present session an attempt has been made to overtake the arrears; and, with the exception of some less important works, the periodicals up to date have been bound—namely, fifty-one octavo and twelve quarto volumes. The honorary librarian begs to point out to members the necessity of entering in the book provided for the purpose any volume borrowed

from the library, for during the present session one or two books have been taken away without this notification and have not been returned. It is in this way that books are liable to be lost. In view of the continued additions to the number of volumes, your Council have increased the sum for which the library is insured to the amount of £1,000. The yearly volume of the Transactions arrived on the 24th October, and was distributed to members as soon as possible.

At the beginning of the session a committee of your Council was appointed to revise the rules and constitution of the Institute, in order to bring them into agreement with the various changes effected by resolutions passed by the members from time to time since 1876, when the rules were last printed. The revised edition was issued to members in April of this year. A resolution was adopted that the Institute should be incorporated under "The Unclassified Societies Act, 1895." This matter will be carried out forthwith.

The fish-hatchery has received a good deal of attention since the last annual meeting. During the recess a deputation of your Council waited on the Minister of Marine, who was passing through Dunedin, in order to urge upon him the importance of proceeding with the matter at the earliest opportunity, and the desirability of appointing a board of management at once. The Minister stated that he considered the matter as practically settled, and your Council indulged in the hope that they might see the building commenced ere the year was out. The lease of the necessary land was drawn up, plans and estimates of the buildings were made, and the Inspector of Fisheries, together with representatives of the Acclimatisation Society and of your Council, visited the proposed site, marked out the position of the tanks, laboratory, house, &c., the Government surveyor received instructions to make a detailed survey and plans, and all looked most promising. But since that date nothing further has been heard of the matter, nor has any board of management been appointed, without which it will be impossible to proceed.

The Philosophical Institute of Canterbury, conjointly with this and other institutes, is engaged in compiling an "Index Faunæ Novæ-Zealandiæ," of which they hope to persuade the Governors of the New Zealand Institute to undertake the cost of publication.

Your Council desire to express their sympathy with Mr. Hamilton and with the publishers of "Maori Art" on the unfortunate accident that has delayed the issue of the final part. Not only were nearly all the copies of Part V. when just completed and ready for issue destroyed by fire, but the blocks used for the illustrations of that part and the embossing of the binding-covers suffered the same fate. It is satisfactory to learn that the loss was covered by insurance, and that the reproduction has now been prepared and will be shortly issued.

The balance-sheet showed the receipts from all sources during the year to be £535 18s. (including £400 on deposit and a balance of £16 0s. 6d. brought forward from last year). The balance on the year's expenditure amounted to £29 11s.

Election of Officers for 1902. — *President* — Professor Benham; *Vice-presidents* — F. R. Chapman and C. W. Chamberlain; *Hon. Secretary* — G. M. Thomson; *Hon. Treasurer*—W. Fels; *Council*—Professor Park, Dr. Hocken, Dr. Colquhoun, Dr. Marshall, A. Hamilton, T. D. Pearce, and A. Bathgate; *Auditor*—D. Brent.

The President then gave an interesting address on the surroundings of the City of Dunedin. On its conclusion he vacated the chair in favour of Dr. Benham.

WESTLAND INSTITUTE.

ANNUAL MEETING: *11th December, 1901.*

Mr. Mahan, President, in the chair.

ABSTRACT OF ANNUAL REPORT.

The report disclosed a very encouraging interest in the Institute during the past year, and it urged members to still further exertions to enlarge the Institute's sphere of usefulness. The membership roll is now fifty-four, and the library had been made much use of by subscribers. During the year over a hundred new works had been added, and a new catalogue was in the hands of the printers, which would shortly be available. The reading-room was well supplied with high-class current periodicals and papers.

The balance-sheet showed a very satisfactory financial position, there being a credit balance of £24.

The trustees desired to thank the Government for their subsidy, the Borough Council for their liberal support, also the Harbour Board for a handsome donation. They also thanked local and other newspapers for free copies.

The Museum had been put on a new basis, and had already been much improved by Dr. Macandrew, who had recently accepted the position of honorary curator.

ELECTION OF OFFICERS FOR 1902.—*President*—Dr. Teichelmann; *Vice-president*—J. B. Lewis; *Hon. Treasurer*—R. McNaughton; *Trustees*—Messrs. Beare, Clarke, Heinz, Michel, Hickson, Morton, Park, Perry, Macfarlane, Mahan, Dawes, and Dr. Macandrew.

HAWKE'S BAY PHILOSOPHICAL INSTITUTE.

First Meeting: *13th May, 1901.*

The President (Mr. W. Dinwiddie) delivered the inaugural address, the subject being "Some Aspects of Technical Education."

Second Meeting: *10th June, 1901.*

Papers.—1. "The Natural History of the Napier–Greenmeadows Road," by F. Hutchinson, jun. (*Transactions*, p. 409.)

2. "Comets, with Special Reference to the Recent Comet," by T. Tanner.

Third Meeting: *8th July, 1901.*

Lecture.—"Pond Life, or Dick's Dive in a Duck-pond," by Dr. Kennedy, M.A.; illustrated by a large number of photo-micrographs.

Fourth Meeting: *18th August, 1901.*

Lecture.—"The Wonders of Creation as revealed by the Telescope," by T. Tanner; illustrated by numerous lantern-slides.

Fifth Meeting: *9th September, 1901.*

Lecture.—"Some Observations on the Fourth Dimension," by the Rev. H. W. Williams; illustrated by a number of diagrams. (*Transactions*, p. 507.)

Sixth Meeting: *21st September, 1901.*

Papers.—1. "Food-adulteration," by Dr. Leahy.

2. "The Vegetable Caterpillar," by H. Hill, B.A., F.G.S. (*Transactions*, p. 396.)

3. "A Philological Study in Natural History," by Taylor White. (*Transactions*, p. 135.)

ANNUAL MEETING: *7th February, 1902.*

ABSTRACT OF ANNUAL REPORT.

During the past year seven meetings of the Institute were held, including the annual business meeting. At the six ordinary meetings seven papers were read and two popular lectures delivered, the attendance of members and the general public being particularly good at the lectures. The Council held seven meetings, at which a considerable amount of general business was transacted.

Early in the session the Borough Council wrote asking upon what terms the Institute would convey the library to the Corporation for use as a reference library. Your Council intimated their willingness to deposit the Institute's books and Museum collections with the Corporation, the books to form part of a reference library, under certain conditions safeguarding members' rights. Nothing further, however, has been done in the matter.

The Institute is again greatly indebted to Misses Spencer and A. Large for a handsome donation—£10—to be spent in the purchase of books for the library. Some of the books have arrived, and, including these, eighteen volumes have been added to the library. It was also decided to subscribe to the *Popular Science Monthly* for a year. A number of parts are to hand, and are available for the use of members.

Mr. C. E. Fox was appointed curator of the Museum, and, with the help of several members of the High School Field Club, was able to overhaul and rearrange a number of the deposits. The Council regret that, owing to Mr. Fox's departure from Napier, his services will not be available for the completion of the work.

Six new members were elected during the year, and there were three resignations, leaving the membership at sixty-four.

The balance-sheet showed the total receipts for the year (inclusive of a balance of £24 11s. 4d. from the preceding year) to have been £88 2s. 4d., while the expenditure was £51 9s. 1d., leaving in hand £36 13s. 3d. Of the Colenso Bequest a balance of £82 12s. remained in hand.

ELECTION OF OFFICERS FOR 1902.—*President*—J. P. D. Leahy, M.B., M.S., B.A., D.P.H.; *Vice-president*—T. C. Moore, M.D.; *Council*—W. Dinwiddie, T. Hall, H. Hill, B.A., F.G.S., F. Hutchinson, jun., J. S. Large, T. Tanner; *Hon. Secretary*—James Hislop, District School; *Hon. Treasurer*—J. W. Craig; *Hon. Auditor*—G. White.

NELSON INSTITUTE.

ABSTRACT OF ANNUAL REPORT.

The receipts for the year ended 31st December, 1901, from all sources (including balance, £65 11s. 4d., brought forward) amounted to £292 11s. 11d., an increase of £56 4s. over the receipts for the previous year. The expenditure amounted to £273 4s. 11d., leaving a credit balance of £19 7s.

The free reading-room, which was opened for the use of the public shortly before our last annual meeting, has undoubtedly met a want much felt by the reading public, and it is evident from the large number of readers frequenting the room that the action of the committee in this direction is fully appreciated.

The sum of £39 8s. 10d. has been spent on books, about a hundred and eighty volumes having been purchased during the year.

The administration of the Institute endowments is in a satisfactory condition.

During the past year the amalgamation of the Philosophical Society with the Institute has taken place, and this Society has taken over the charge of the Museum, and the Nelson Philosophical Library is now merged in the library of the Nelson Institute.

After the amalgamation of the societies had been effected this Society applied to the New Zealand Institute for affiliation, and the request has been granted. A scientific branch of the Institute has been formed, with an additional subscription of 5s. per annum, which will confer the privilege of receiving the "Transactions of the New Zealand Institute." Many members have availed themselves of this arrangement.

The committee desire to record their thanks to those members who have presented newspapers and periodicals, and to those who have generously presented books, and again express their appreciation of the efficient and zealous manner in which the duties of librarian have been performed by Miss Reeves.

ELECTION OF OFFICERS FOR 1902.—*President*—H. W. Robinson; *Vice-president*—D. Grant; *Hon. Secretary and Treasurer*—A. J. Redgrave; *Acting-Curator of Museum*—W. F. Morley; *Librarian*—B. Reeves.

APPENDIX

METEOROLOGY.

Comparative Abstract for 1901 and Previous Years.

Stations.	Barometer at 9.30 a.m.		Temperature from Self-registering Instruments read in Morning for Twenty-four Hours previously. Fahr.					Computed from Observations.		Rain.		Wind.		Cloud.
	Mean Reading.	Extreme Range.	Mean. Temp. in Shade.	Mean Daily Range of Temp.	Extreme Range of Temp.	Max. Temp. in Sun's Rays.	Min. Temp. on Grass.	Mean Elastic Force of Vapour.	Mean Degree of Moisture (Saturation = 100).	Total Fall in Inches.	No. of Days on which Rain fell.	Average Daily Force in Miles for Year.	Maximum Velocity in Miles in any 24 hours, and Date.	Mean Amount (0 to 10).
Auckland...	30·028	1·250	58.3	10·8	37·0	152·0	33·0	0·336	68	38·150	176	...	...	5.5
Previous 37 years ...	29·999	...	58·8	...	...	...	...	0·380	71	41·889	180	...	...	...
Wellington	29·674	1·834	54·9	12·0	49·0	140·0	22·0	0·295	68·5	46·350	175	242	695 on 17th Oct.	4·6
Previous 37 years ...	29·927	...	54·9	...	...	...	...	0·330	72	51·029	161	...		...
Dunedin	29·620	1·506	56·75	12·9	58·0	...	...	0·273	76	37·637	173	156	570 on 4th Sept.	5·9
Previous 37 years ...	29·952	...	49·9	...	...	...	...	0·274	73	36·915	157	...		...

Average Temperature of Seasons compared with those of the Previous Year.

Stations.	Spring. September, October, November.		Summer. December, January, February.		Autumn. March, April, May.		Winter. June, July, August.	
	1900.	1901.	1900.	1901.	1900.	1901.	1900.	1901.
Auckland	57·4	57·0	64·6	63·4	62·9	59·5	53·6	53·0
Wellington	53·6	56·2	60·0	60·6	57·4	56·6	48·6	48·3
Dunedin	51·4	50·8	55·2	54·9	51·2	50·1	42·9	41·6

REMARKS ON THE WEATHER, 1901.

JANUARY.—Fine weather with light rain in the extreme North; warm N.E. breezes with good rains over the centre and South.

FEBRUARY.—Showery in the centre throughout the month; fine in North and South. W. and S.W. winds prevailed in the South Island.

MARCH.—S. and S.W. winds were general all over the colony, with fine weather in the South Island.

APRIL.—Heavy gales from N.W.; thunder on 18th over the South Island; prevailing S.W. winds in South.

MAY.—Gales from the S.W. in the North, with light rain showers; good rains in south of North Island, with prevailing N.W. wind. N.W. gales with heavy rain on West Coast; in the South S.W. gales.

JUNE.—In the North N.E. and S. winds prevailed; heavy rains in south of North Island and West Coast; light rains on East Coast; thunder and gales in South Island.

JULY.—In the early part of the month cold S.W. winds were general all over the colony; heavy snow fell in the South. The end of the month was fine in the North, while there were heavy rains in the South.

AUGUST.—S.W. wind in the North was again strong early in the month; the rainfall was under the average over the centre; on West Coast E. and S.W. winds with heavy rains.

SEPTEMBER.—In the North N.E. and S.W. winds; fine weather and good rains in south of North Island; S.W. winds all over South Island; heavy rain on West Coast.

OCTOBER.—Weather fine in the South, with small rainfall; prevailing wind from west. Heavy N.W. and S.W. gales with heavy rains over West Coast; in the North fine weather, with prevailing N.W. wind.

NOVEMBER.—S.W. winds with moderate rainfall all over North Island; heavy gales from S.W. all over South Island; heavy rains West Coast.

DECEMBER.—Local N. and N.E. winds in extreme South, but over rest of the colony S.W. wind prevailed; moderate rainfall everywhere except West Coast.

EARTHQUAKES reported in NEW ZEALAND during 1901.

PLACE.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Rotorua ..	..	..	29, 30*	2	..	15, 18	14, 18	25	21	..	..	20	10
Waiotapu ..	..	..	..	..	..	..	..	..	6	..	..	..	1
Gisborne ..	..	..	14	..	..	..	..	..	..	..	..	..	1
Napier ..	31	..	..	..	..	..	11	..	..	24	..	..	3
New Plymouth ..	3	7, 13	..	..	..	6	..	..	20	..	14, 16	..	7
Hawera ..	..	14*	..	..	..	..	..	..	..	..	..	..	1
Waipawa ..	..	..	..	..	..	..	..	..	..	24	..	..	1
Eketahuna ..	..	..	..	11	..	..	..	..	..	..	..	..	1
Palmerston North	..	..	..	11	..	..	..	..	..	..	..	..	1
Wanganui ..	..	14*	..	..	..	..	17	..	..	..	..	..	2
Masterton ..	..	..	..	11*	..	..	..	..	..	..	..	..	1
Greytown ..	..	..	..	11	..	..	..	..	..	..	..	..	1
Levin ..	..	..	..	11	..	..	..	..	..	..	..	..	1
Carterton ..	..	..	..	11*	..	..	..	..	20	..	..	..	2
Feilding ..	..	..	..	..	..	..	..	..	..	24	..	..	1
Wellington ..	18	7, 14	14, 15	1, 3	..	6	..	12	19	..	14, 16	3, 12, 29	15
Blenheim ..	..	14*	..	..	..	..	..	..	..	..	..	..	1
Nelson ..	..	14*	..	..	..	..	..	..	..	..	..	..	1
Cheviot ..	..	..	..	..	..	..	..	..	..	..	17,*18,*19, 21,* 30	2, 6*	7
Kaiapoi ..	..	..	..	..	..	..	..	..	..	..	17, 19	..	2
Lincoln College ..	..	..	..	..	..	..	..	..	..	..	16	..	1
Christchurch ..	..	..	..	..	..	..	..	..	..	..	17,* 25	..	2
Hokitika ..	..	..	..	..	..	..	..	..	..	..	17	..	1
Dunedin ..	22	..	..	..	9	..	..	..	..	..	3, 16, 18	..	5

NOTE.—The figures denote the day of the month on which one or more shocks were felt. Those with the asterisk affixed were described as *smart*. The remainder were only slight tremors, and no doubt escaped record at most stations, there being no instrumental means employed for their detection. These tables are therefore not reliable as far as indicating the geographical distribution of the shocks within New Zealand. The records of the Milne seismographs recently established at Wellington and Christchurch will be found on pp. 598–607.

Records of Milne Seismograph No. 20, at Wellington, from October, 1900, to December, 1901 (inclusive).

Plates XLI. and XLII.

Latitude, 41° 17′ S.; longitude, 174° 47′ E. Time employed, 11 h. 30 m. east of Greenwich (New Zealand mean time). Midnight, 0 h. or 24 h.; hours, 1 to 24.

Record numbers 1, 2, . . . from the 1st October, 1900. P.T., preliminary tremors. A.T., after-tremors. B., E., beginning and end of vibrations generally not less than 2 mm. Amp., full amplitude in millimetres.

The period of the boom of the pendulum during the currency of these records was kept as near to 16½ seconds as possible. The instrument is placed in a special room below a house standing about 30 ft. from the edge of a rocky cliff about 50 ft. high, situated about 250 yards from the shore-line of Wellington Harbour.

George Hogben, Observer.

No.	Date.		P.T. (from)	B.	Maxima.		Amp.	E.	A.T. (till)	Remarks.
					From	To				
	1900.						Mm.			
1	Oct.	3	13.17	?	17.41	..	2	..	..	Two maxima.
						20.40	6	?	22.45+	
2	"	4	1.57	?	2.52½	..	1·5	..	..	"
						3.8½		?	8.16	
3	"	4	8.51	9.51	9.52½	..	..	..	..	"
						11.9	2	11.9	12.5	
4	"	4	17.8	..	17.8	..	small	..	8.5 +	
5	"	5–6	23.57	2.48	2.56	..	..	3.4	4.50	Tremors; 5, 6, and 7 are continuous.
6	"	6	4.56	6.33½	6.35	..	13	6.38	9.53+	
7	"	6	9.53	..	13.17	..	..	..	..	Two maxima.
						14.1	2	..	15.4	
8	"	8	2.4	2.25	2.52	..	2·5	..	..	"
						3 8		3.23	6.40	
9	"	8	6.42	8.54½	9.1	9.9	22	9.28	10 20	

10	Oct. 8	12.17	..	..	..	..	..	13.50+	Minute tremors.
11	„ 8	..	20.7	20.37	..	7	20.49	21.37	
12	„ 8	22.10	..	..	..	..	..	..	
	„ 9	..	..	..	..	..	..	1.50	
13	„ 9	2.50	..	..	..	..	..	8.4	„
14	„ 9	..	8.4	$8.51\frac{1}{2}$	..	1·5	9.4	19.30+	
15	„ 10	?	0.36	0.56	..	11	..	..	Origin in Alaska.
					2.17	8	2.43	?	
16	„ 16	..	22.43	$22.48\frac{1}{2}$	..	..	?	$22.54\frac{1}{2}$	Small local shock.
17	„ 21	4.59	6.18	6.25	..	3·5	?	6.56	
				$6.28\frac{1}{8}$	6.30				
18	„ 22	12.7	..	..	..	..	..	16.31	Very small tremors.
19	„ 23	10.32	..	..	..	..	..	15.25	„
20	Nov. 24	..	..	23.34	..	..	..	..	Nine small local shocks.
	„ 25	..	..	..	6.32				
21	„ 25	..	..	$21.18\frac{1}{2}$	..	..	..	..	Small local shock.
22	Dec. 16	..	11.37	12.29	..	9	13.25	..	Nine small shocks, one large.
23	„ 17	..	8.4	8.14	..	2·5	8.35	..	Five small shocks.
24	„ 17	..	11.53	12.14	..	5	12.53	..	Seven small shocks.
25	„ 18	..	8.28	9.15	..	4·5	9.26	..	Six small shocks.
				$9.57\frac{1}{2}$	10	38		18.37	Large tremors.
26	„ 19	..	9.55	10.6	..	10	10.56	21.54	Small tremors.
				$10.46\frac{1}{2}$	10.51	8		..	
27	„ 23–24	5.55*	18.57	18.57	..	8	19.1	3.41+	Minute tremors for some hours after.
28	„ 24	10.25*	..	..	..	..	..	18.45*	Small tremors.
29	„ 25–26	18.30*	..	..	..	..	..	5.20*	Tremors.
30	„ 26–27	12.18	18.8	18.9	..	2·5	18.17	10.38	Many small shocks.
31	„ 27	11.42	..	..	..	..	..	12.57	Tremors.
32	„ 28	8.43	?	$9.53\frac{1}{2}$	..	2	..	14.38	Slight; ? local.
33	„ 30–31	15.0*	..	..	..	..	..	5.30*	Tremors and slight shocks.
34	„ 31	..	11.24	..	..	..	..	..	Centre line changing position.
	1901.								
	Jan. 1	..	..	..	..	..	0.28	..	Wave in centre line (see record for January, 1901). No tremors or shocks.

Record defective for most of month of November owing to absence of observer.
Record incomplete during first part of December.
* About.

RECORDS OF MILNE SEISMOGRAPH No. 20—*continued.*

No.	Date.		P.T. (from)	B.	Maxima. From	Maxima. To	Amp.	E.	A.T. (till)	Remarks.
	1901.						Mm.			
35	Jan.	1	..	..	..	..	..	..	..	Wave in centre line ; period, 13 h. 4 m. ; complete amplitude, 6·5 mm.
36	„	2	19.34	..	22.33$\frac{1}{2}$	22.46$\frac{1}{2}$	3	22.53	23.25+	
37	„	3	bef. 19.36	0.3	0.5$\frac{1}{4}$	..	2·5	0.7	..	Continuous tremors from 19.36 on the 3rd January to 16.34 on the 6th January.
	„	4	..							
	„	5	..							
38	„	6	..	9.6$\frac{1}{2}$	9.13	..	2·5	9.19	16.34+	Lamp went out at 16.34.
39	„	6	21.53	22.55$\frac{1}{2}$	23.0	23.26	..	..	..	No. 39 is continuous with No. 40.
40	„	7	..	..	1.2	..	23.0	..	..	Also smaller shocks at 1.7, 1.14, 1.43, 1.46$\frac{1}{2}$, 2.38, 2.46, 4.52, &c., with tremors between.
	„	7	12.21$\frac{1}{2}$	12.43$\frac{3}{4}$	12.51	..	7·5	12.59$\frac{1}{2}$	..	The tremors that had been going on for some days became more marked at 12.21$\frac{1}{2}$.
41	„	8	1.20	?	3.49	..	1	..	..	Followed by other maxima at 9.53 and 10.9$\frac{1}{2}$.
	..		..	..	..	4.19	1	..	..	
42	Jan.	8	..	10.44	10.51	..	2	10.53		
	..		..	12.38	12.51	..	1·5	12.55	..	Followed by other maxima at 14.5, 14.14, 15.23, 15.44$\frac{1}{2}$, 16.3, 16.11, 17.0$\frac{1}{2}$.
43	Jan.	8	..	?	21.33	..	3·5	?	..	? Local. Followed by other slighter shocks till 5.24, 9th January.
44	„	9	..	..	0.33	..	38	..	..	
	..		..	..	..	4.57$\frac{1}{2}$	11			
45	Jan.	9	9.30	9.31	9.58$\frac{1}{2}$	..	4	..	..	Probably local.
					10.10	..	2·5			
					10.33	..	4			
					11.5	..	7			
46	„	9	..	12.53	12.59	..	?	13.0$\frac{1}{2}$	..	With other smaller maxima.

47	Jan.	14	4.49	?	7.40½	..	1			
						15.14	..	..	18.25	..
48	„	15	10.32	..	..	..	..	..	..	Minute tremors.
	„	16	..	..	..	..	..	..	17.48	
49	„	18	8.29	..	..	..	..	..	?	Minute tremors till after 9.59, when lamp went out.
50	Feb.	4	10.30	..	18.30½	..	5	..	..	Large tremors; no distinct earthquake.
	„	5	..	..	..	..	..	..	7.39	
51	„	5	9.57	..	..	..	2·5	..	12.52	Tremors; no marked shocks.
52	„	5	21.41	..	..	..	..	..	..	Minute tremors.
	„	6	..	..	..	..	..	..	6.18	
53	„	6	6.18	7.55½	7.57½	..	13·5	?	..	After-tremors of great length.
	„	7	..	..	..	..	..	..	15.11	
54	„	8	7.42	..	..	..	..	..	18.34	Tremors.
55	„	10	..	7.13	7.13	..	7	7.14	..	Local.
56	„	10	..	8.32	8.33	..	4·5	8.33½	..	„
57	„	10	..	9.32	9.36	..	2	9.36	..	„
58	„	10	..	14.31	14.32	..	2·5	14.32	..	Local; tilt 2 mm. to west.
59	„	10	..	15.42	15.42	..	3	15.42	..	Local; tilt 1·5 mm. to east.
60	„	19	..	16.29½	16.34	..	16	16.36½	..	Local.
61	„	10	..	19.5	19.5	..	6	19.5	..	Local; tilt 2 mm. to east.
62	„	10	..	19.28	19.33	..	3	19.34½	..	Local.
63	„	10	..	?	22.48½	22.53	3·5	?	..	Local; tilt 0·5 mm. east.
64	„	10	..	23.29	23.36½	..	5	23.39		
65	„	11-14	..	..	..	..	..	..	..	A few minute tremors.
66	„	20	2.44	3.15	3.18	..	1	3.19	3.23	Local.
67	March	15	..	?	23.17	..	?	?	..	Very small; local.
68	„	16	..	?	21.37	..	4	?	..	Change of level; local.
69	„	19	..	?	3.21	..	1	?	..	Local.
70	„	23	..	?	16.35	..	?	?	..	Very small; local.
71	April	30	..	4.42	4.42	..	5	4.42½	..	Local.
72	„	30	..	4.59	4.59	5.0	4	5.0⅓	..	Local; two maxima.
73	„	30	..	5.17	5.17	..	29	5.17½	?	Local; tilt 4 mm. to west; after-tremors for nineteen hours.

Record defective for first ten days of April; clock out of order. Again from 17th to 25th April; clock out of order.

Records of Milne Seismograph No. 20—*continued.*

No.	Date.		P.T. (from)	B.	Maxima. From	Maxima. To	Amp.	E.	A.T. (till)	Remarks.
	1901.						Mm.			
74	May	3	10.52	..	..	..	..	..	21.20	Very small tremors.
75	„	4	5.20	9.39	9.40½	..	4	9.43	..	Continuous tremors between; followed by minute tremors.
76	„	4	..	15.47	15.53	..	3	15.59	16.24	
77	„	5	1.33	..	..	..	..	..	..	Large tremors from 12.45 to 13.50; rest small or minute tremors.
	„	6	..	..	..	..	..	..	0.6	
78	„	6	4.15*	..	..	..	..	..	18.15*	Very small tremors.
79	„	7	1.11	..	..	..	..	..	17.47	Small to very small tremors.
80	„	8	5.33	..	..	..	..	..	12.15	Very small tremors, followed by minute tremors till 15.25.
81	„	9	10.33	..	..	..	..	..	20.30	Very small tremors.
82	„	9	21.17	..	..	..	..	..	..	Tremors gradually increasing from minute to moderate (1 or 1·5 mm).
	„	10	..	..	..	..	..	..	8.30*	
83	„	10	8.32	9.26	9.26½	..	1·5	..	..	10–11 May: chief maxima, as named.
	„	10	..	..	10.45¾	..	3·5	..	..	Also at 10.54¾ (2·5 mm.), 10.57½ (2·5 mm.).
	„	10	..	..	11.27¼	..	3·75	..	..	Also at 12.13 (2 mm.), 13.3 (3 mm.), 14.36¼ (2 mm.).
	„	10	..	..	17.6¼	..	3·5			
	„	10	..	..	17.47	17.50½	3	..	..	Also at 19.17–19.26¼ (2.5 mm.) and 19.58 (2·5 mm.).
	„	10	..	20.15½	20.47	..	5	..	..	Also at 22.6, 22.24, and 22.32 (all 3 mm.).
	„	10	..	22.52½	22.54¼	23.6¼	4·75	..	..	Also at 0.10, 0.13, 0.18½ (all 2.5 mm.).
	„	11	..	0.42	0.48	0.51	3·75	0.57	3.29	
84	„	11	3.54	..	..	..	..	..	11.53	Very small tremors.
85	„	11	..	19.24	19.27	..	1	19.28	..	? Local.
86	„	12	..	1.48	1.48	2.6	3	2.6	..	Probably local.
87	„	13	2.38	2.51	2.51	..	2	2.51	..	? Local.

88	May	17	..	15.36	15·36	..	?	15.36	..	Very small local shocks.
89	″	17	..	22.30	22.30	..	?	22.30	..	
90	″	18	0.30	..	..	..	..	..	10.32	Tremors, minute, with a few moderate
91	″	19	5.15	..	..	..	..	..	15.12	Minute tremors.
92	″	22	5.28	..	..	..	..	..	19.24½	″
93	June	6	..	..	13.26	..	..	..	..	Local; level tilted 4 mm. to west.
94	″	6	18.11	..	..	..	..	..	20.42	Very small tremors.
95	″	6	20.52	..	..	..	..	..	..	Minute tremors.
	″	7	..	..	..	..	..	..	4.11	
96	″	10	..	17.49	17.51	..	5	17.53	..	Local.
97	″	11	..	2.32½	2.34	..	4	2.37	..	″
98	″	27	?	22.47	22.47	23.51	2–3	23.54	..	Fifteen shocks, or maxima; eighteen similar shocks of shorter duration, till about 2.45 on the 29th June.
99	″	29	..	13.48	13.51	14.2	6	14.6	..	Local.
100	″	29	..	14.29½	14.30	14.32½	..	14.37	..	″
101	″	29	..	15.53	16.2	..	..	16.27	..	? Local.
102	″	29	..	17.31½	17.31½	..	7	17.49	..	″
103	″	29	..	18.43	18.51	..	5	18.56	..	″
104	″	29–30	..	23.35	23.45	23.57	4	0.1	..	″
105	″	30	..	0.54	0.54	1	7	1.6	..	″
106	″	30	..	3.41½	3.42	..	4	3.49	..	″
107	″	30	..	10.49	10.55	..	6	11.5	..	″
108	″	30	..	12.54	12.56	13.5	3	13.8	..	″
109	″	30	..	13.40	13.40	13.41	4	13.45	..	″
110	″	30	..	18.1	18.6	..	5·5	18.9	..	″
111	″	30	..	21.26	21.26	21.47	4	21.52	..	″
112	″	30	..	23.3	23.3½	..	10	23.28	..	″
113	July	1	..	1.30	..	..	..	22.45	..	Eleven shocks similar to those of 29th June, but shorter.
114	″	3	10.46	..	..	..	..	..	14·22	Small tremors.
115	″	4	6.37	..	..	..	..	..	17.38	″
116	″	19	21.19	..	..	..	..	..	23.34	Very small tremors.
117	″	21	6.9	..	..	..	..	..	14.13	Tremors, minute for about seven hours, then small.

* About.

It is possible, but not likely, that some of the shocks from the 27th to the 30th June may be instrumental.

RECORDS OF MILNE SEISMOGRAPH No. 20—*continued.*

No.	Date		P.T. (from)	B.	Maxima. From	Maxima. To	Amp.	E.	A.T. (till)	Remarks.
	1901.						Mm.			
118	July	25	9.37	..	..	..	..	..	19.45*	Minute tremors.
119	"	26	6.30*	..	..	..	..	..	8.25*	"
120	"	29	22.6	..	..	..	..	..	..	Tremors.
	"	30	..	..	..	..	..	..	6.24	
121	"	30	10.39	..	..	..	..	..	14.43	"
122	"	30	15.39	22.0	22.4	22.6	3·5	?		
	"	31	..	..	..	..	..	..	13.25	
123	Aug.	2	2.14	..	..	..	..	..	9.47	Small tremors.
124	"	2	15.36	..	..	..	..	..	..	"
	"	3	..	..	..	..	..	..	19.24	
125	"	4	3.20	..	..	..	..	..	..	Very small tremors, with intervals of rest.
	"	5	..	..	..	..	..	..	0.55	
126	"	6	19.48	..	..	..	..	..	19 55	Tremors.
127	"	9	21.8	21.35	22.4	..	6	22.12	23.6	
128	"	10	..	0.38	0.51	1.25†	>40	2.46	?	
129	"	10	?	3.36	3.44	4.10	5	4.17	5.4	
130	"	10	6.0	6.44	7.11	7.23	4	7.26	9.20+	
131	"	10	21.59	22.18	22.23	22.33	6	22.38	23.43	
132	"	11	3.33	3.34	3.35½	3.39	2	3.42	..	Probably local.
133	"	11	6.22	..	..	..	..	..	6.35	Tremors.
134	"	11	9.12	..	..	..	..	..	9.26	"
135	"	11	17.34	..	..	..	..	..	22.28	Minute tremors.
136	"	12	1.36	2.7	2.12	2.24	11	2.40	4.4	
137	"	13	7.37	..	..	..	..	..	7.52½	Small tremors.
138	"	13	21.5	..	..	..	..	..	..	Tremors, large and small.
	"	14	..	..	..	..	..	..	14.48	
139	"	14	18.10	..	..	..	..	..	18.41	Small tremors.
140	"	14	20.37	..	..	..	..	..	..	Tremors, moderate to minute,
	"	15	..	..	..	..	..	..	23.8	

141	Aug.	16	8.40	..	..	..	..	..	9.34	Minute tremors.
142	"	16	20.37	..	..	..	..	..	21.11	Tremors.
143	"	17	7.45	..	..	..	..	..	..	Minute tremors, dying away slowly.
	"	18	..	..	..	..	..	..	6.41	
144	"	19	7.38	..	..	..	..	..	..	Minute for 25½ hours, then moderate to large.
	"	20	..	..	..	..	..	..	20.46	
145	"	20	21.6	..	..	..	..	..	..	Tremors.
	"	21	..	..	..	..	..	..	6.2	
146	"	21	18.43	..	..	..	..	..	..	
	"	23	..	..	..	..	..	..	21.49	"
147	"	25	..	9.11	9.11	..	3	9.11½	..	? Local.
148	"	25	..	9.35	9.36	..	11	9.36½	..	Two maxima.
149	"	25	..	10.41	10.41	..	26	10.43		
150	"	28	4.37	..	..	..	..	..	..	Long series of vibrations.
	"	29	..	?	9.24	..	2–3	..	17 0	
	"	30	..	..	..	1.28		..		
151	Sept.	4	8.15	..	..	..	..	..	..	Minute tremors, with intervals of rest.
	"	5	..	..	..	..	..	..	19·1	
152	"	6	8 4	..	..	..	..	..	19.4	" "
153	"	7	19.7	..	..	..	..	..	21.37	" "
154		8	10.30	10.38	10.41	10.45	4	11.0½	11.18	
155		9	5.19	5.31	5.32	5.33½	16	5.36	..	After-tremors, many large, with intervals of rest.
	"	10	..	..	..	..	..	..	19.20	
156	"	10	20.44	..	..	..	..	..	..	Tremors, minute at first.
	"	11	..	..	..	..	..	..	5.2	
157	"	11	8.43	..	..	..	..	..	9.14	Very small tremors.
158	Oct.	19	..	9.21	9.21	9.33	1·5	9.34	..	Three maxima. ? Local.
159	Nov.	16	..	7.47	7.47½	7.49¼	>40	7.58¼	8.58	Local. Earthquake in Cheviot district, Canterbury and Nelson. Large tremors till 8.58, followed by continuous small tremors (with very few intervals) and many small shocks until 17 h. on the 19th November, with intensity IX. on Rossi-Forel scale.
	"	19	..	..	..	..	..	..	17.0	
160	"	20	10.30*	..	..	..	..	..	19.0*	Very small or minute.

The clock was out of order and was away for repairs during part of October.

* About. † Other maxima or large tremors up to 10 mm. in amplitude for more than one hour later

Records of Milne Seismograph No. 20.—*continued.*

No.	Date.		P.T. (from)	B.	Maxima. From	Maxima. To	Amp.	E.	A.T. (till)	Remarks.
	1901.						Mm.			
161	Nov.	21	6.20*	?	11.18½	..	1	?	..	Tremors; local.
	″	22	..	..	..	..	..	..	0.20	
162	″	23	2.45*	..	..	..	..	..	..	Minute to small tremors.
	″	25	..	..	..	..	..	..	*13.30	
163	″	25	13.32	13.50	13.53	13.56	8	14.2	14.56	Probably non-local.
164	″	25	19.25	..	..	..	..	..	..	Tremors; probably local.
	″	26	..	..	..	..	..	..	13.20	
165	″	27	7.35	..	..	..	..	..	18.20	″ ″
166	″	28	2.37	?	7.44½	†8.29¾	2·5	..	17.3	
167	″	29	3.50	..	..	..	..	..	11.40	Moderate.
	″	30	..	..	..	..	..	..	18.18	Minute.
168	″	31	20.4	..	..	..	..	..	..	Very small tremors.
	Dec.	1	..	..	..	..	..	..	8.47	
169	″	1	..	..	8.52½	..	2	8.58½	..	Tremors between.
170	″	1	?	9.46	9.48½	..	8	9.51	..	
171	″	22	..	1.34	1.34	..	1	1.38	..	Local.
172	″	23	..	6.15¾	6.16¾	..	2·5	6.19¼	..	″
173	″	23	..	8.26½	8.26½	..	2·5	8.29½	..	″
174	″	24	..	7.7¼	7.7¼	..	1	7.9	..	? Local.
175	″	25	..	11.21	11.47¾	..	3	11.51½	..	″
176	″	25	..	14.45	14.45	..	3·5	14.47½	..	Local.
177	″	26	14.9	..	14.41	..	..	..	14.44	Minute tremors.
178	″	26	21.38	21.40½	21.44¼	21.49¼	6·5	22.7	23.14¾	
179	″	27	10.4	..	..	..	..	..	12.10	″
180	″	27	..	21.53½	21.53½	..	4	21.57	..	Local.
181	″	28	5.0	..	14.6¾	..	2	..	20.7¼	Tremors, mostly minute or very small.
182	″	31	20.56	21.21¼	21.25¾	..	2	21.28½	21.38	

Many minute tremors and small shocks separated by longer intervals from 1st to 22nd December; probably all local (Cheviot).
* About. † Other maxima till 11.4. Tremors marked but small, dying away to minute.

Records of Milne Seismograph No. 16, at Christchurch, from November, 1901.

Latitude, 43° 31′ 50″ S.; longitude, 172° 38′ 09″ E. Time employed: 11 h. 30 m. east of Greenwich.

Numbers 1, 2, . . . from November, 1901. Time: N.Z.S.T., as stated above. P.T., preliminary tremors less than 2 mm. complete amplitude; A.T., after-tremors less than 2 mm. complete amplitude; B., E., beginning and end of vibrations not less than 2 mm.; Amp., full amplitude in millimetres; B.P., boom period; midnight, 0 h. or 24 h.

Records were commenced on this instrument on the 19th November, 1901. The instrument is erected on a brick pillar standing on a concrete foundation sunk to a depth of about 4 ft. 6 in. The concrete is of the form of a truncated pyramid of square section, the length of whose side at the bottom is 4 ft. 6 in. and on the top 1 ft. 6 in., from which rises the square-sectioned brick pillar referred to. The geological formation is an alluvial plain of considerable thickness, in which are several water-bearing strata. From these the people of Christchurch derive their artesian water.

C. Coleridge Farr, Observer.

No.	Date.		P.T. (from)	B.	Maxima.		Amp.	E.	A.T. (till)	B.P.	Remarks.
					From	To					
	1901.						Mm.			Secs.	
1	Nov.	23	..	..	16.19	16.22	1				
2	"	25	13.0	13.48	13.49	13.50½	3	13.52	14.30	20	
3	Dec.	6	..	..	1.0	1.1½	2				
4	"	6	5.1.30	..	5 13.50	5.13.50	5	5.14.20	7.30?	20	
5	"	7	?	1.42.10	1.43.40	1.43.40	8	1.57.20	?	20	Tremor slow before and after.
6	"	9	2.13	2.36.20	2.37.30	2.39.50	3·3	2.40.20	4.12	20	
7	"	15	10 40	10.59	11.6	11.6	3·5	11 24	12.30	15	
8	"	27	..	..	19.49.30	..	1·2	..	20.0	17	
9	"	31	10.20	10.56.27	10.59	11.2	3	11.6.35	12.55	18	
10	"	31	18.1.17	..	18.8:4	18.11.27	1·3	..	18.40	18	
11	"	31	20.56.35	20.57.24	21.22.30	..	9	21.51	25.30	18	
					21.28.30	..	26				
					21.31.46	..	8				
					21.33.45	..	6				

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Society of Geography, Leipzig.
Naturhistorischer Verein in Bonn.
Natural History Museum of Hamburg.
Naturwissenschaftlicher Verein, Bremen.
Redaktion des Biologischen Centralblatts, Erlangen.
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R. Accademia dei Lincei, Rome.
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Musen Paulista, San Paulo, Brazil.
Zoological Society, Brazil.

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Executive Library.
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Library, Wellington Philosophical Society.
Library, Nelson Institute.
Library, Westland Institute.
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Library, University College, Christchurch.
Library, University College, Dunedin.
Library, Auckland Museum.
Library, Wanganui Museum.
Library, Canterbury Museum.
Library, Otago Museum.
Library, Otago School of Mines.
Library, Thames School of Mines.
Library, Reefton School of Mines.
Library, Free Public, Auckland.
Library, Free Public, Wellington.
Library, Free Public, Christchurch.
Library, Free Public, Dunedin.

Publishing Branch.

Editor.	Lithographer.
Assistant Editor.	Government Printer.
Draughtsman.	Photo-lithographer.

INDEX.

AUTHORS.

SUBJECTS.

JOHN MACKAY, GOVERNMENT PRINTER, WELLINGTON.—1902.

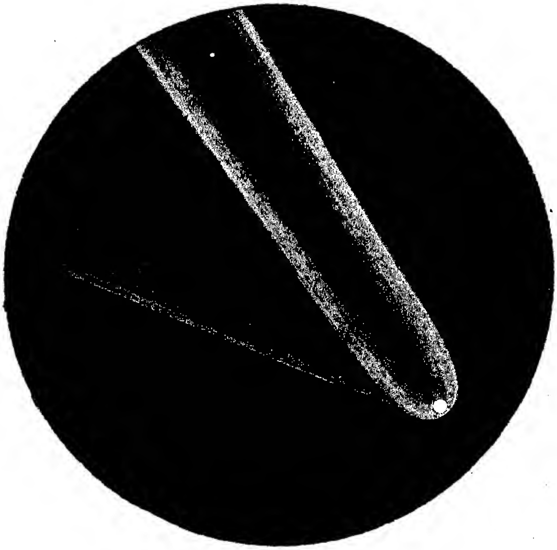


Fig. 1.

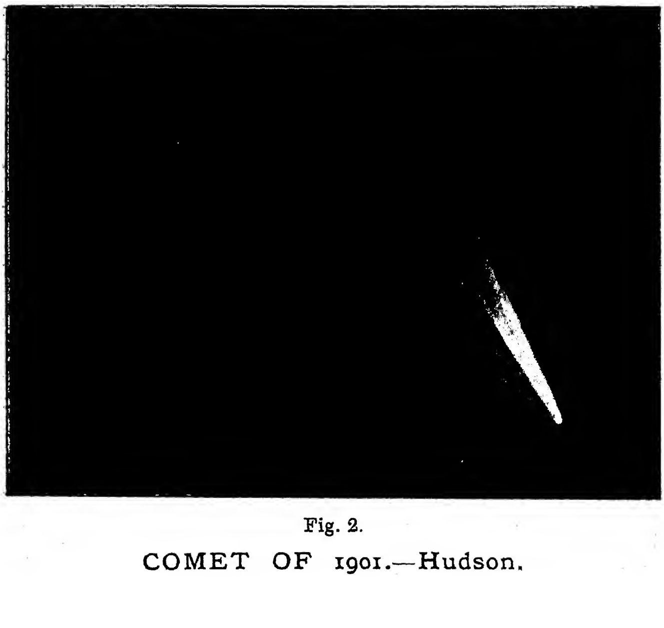
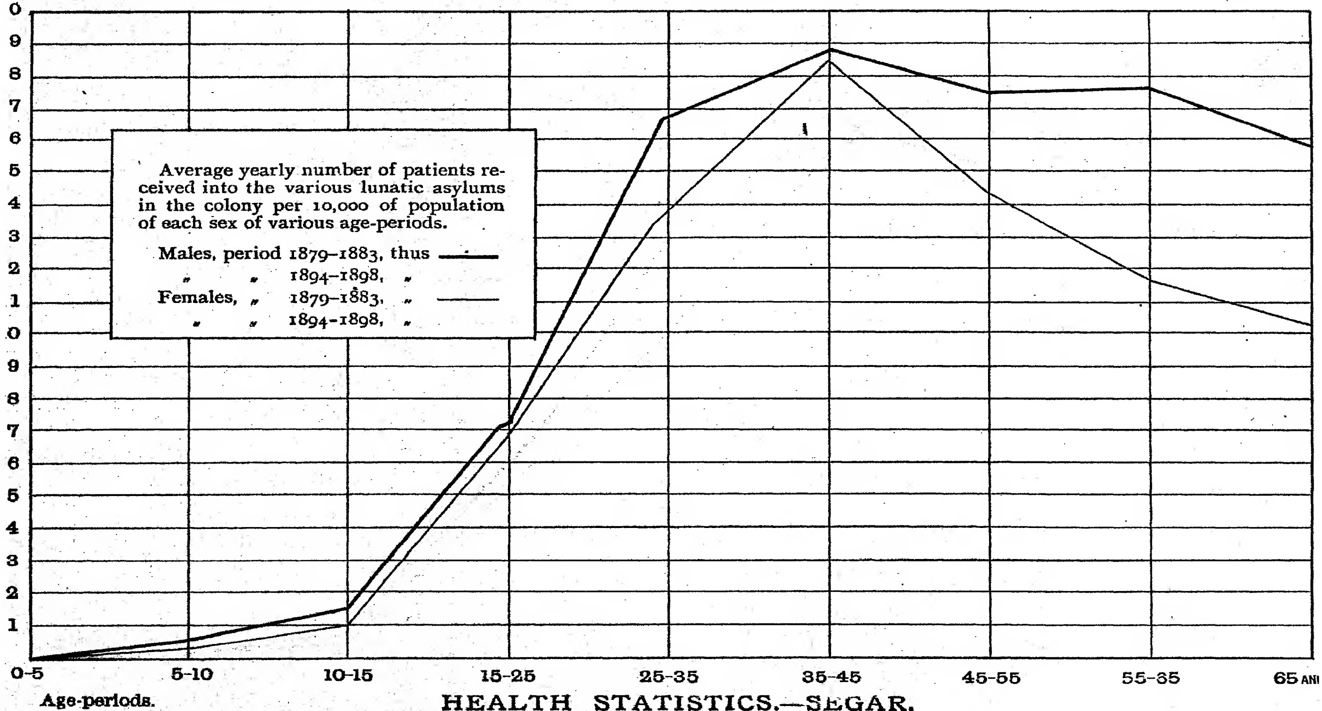
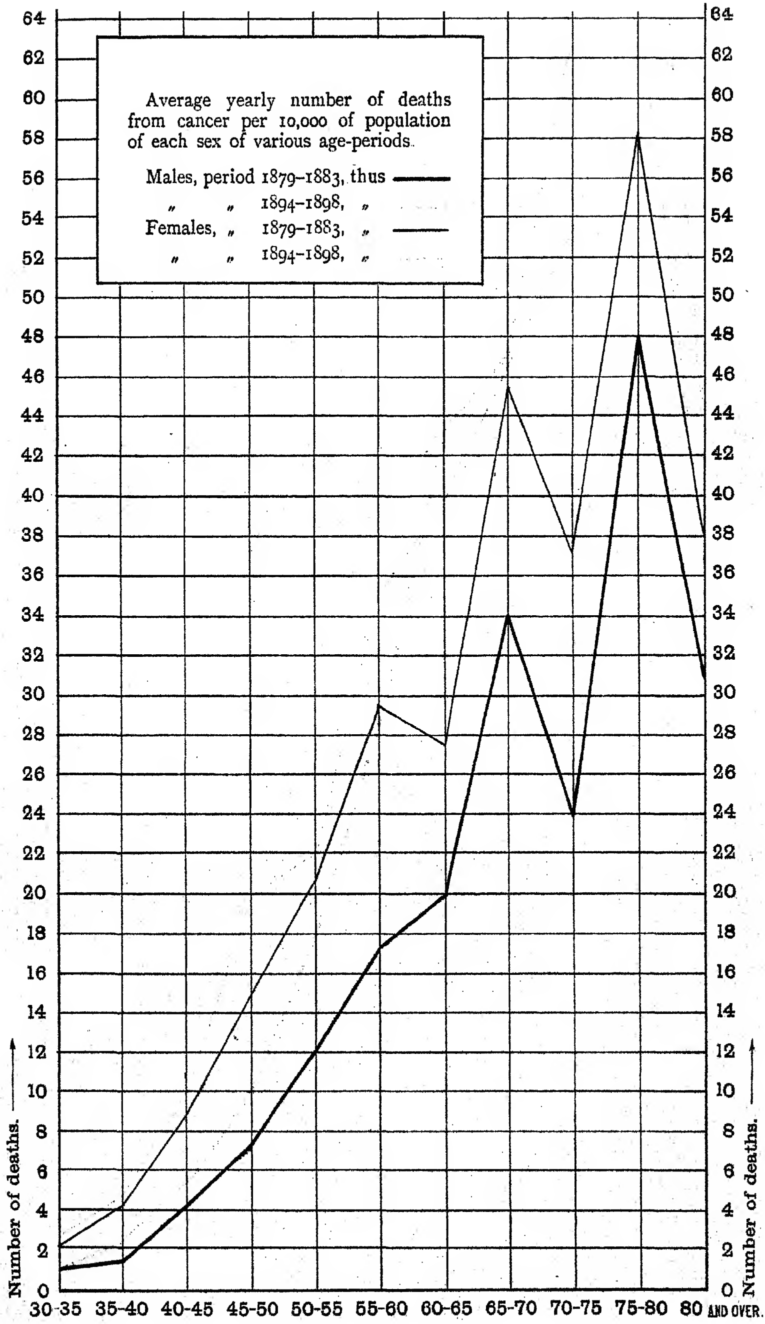


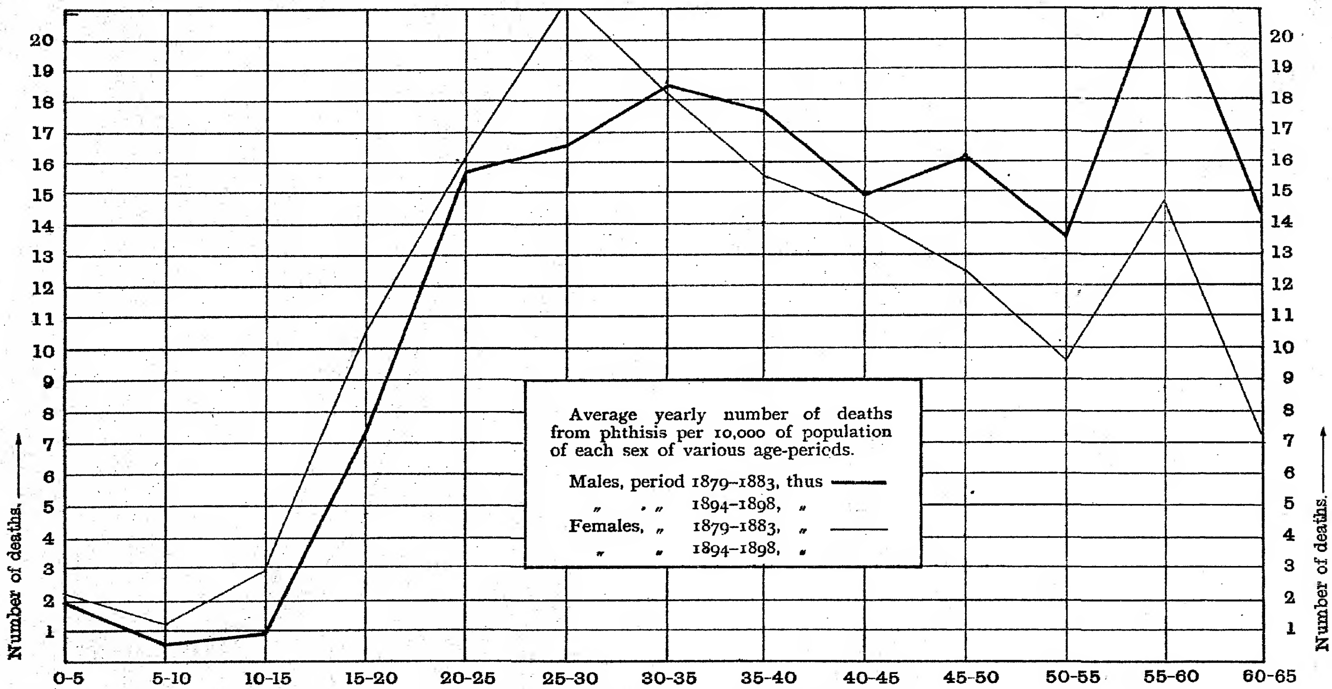
Fig. 2.

COMET OF 1901.—Hudson.

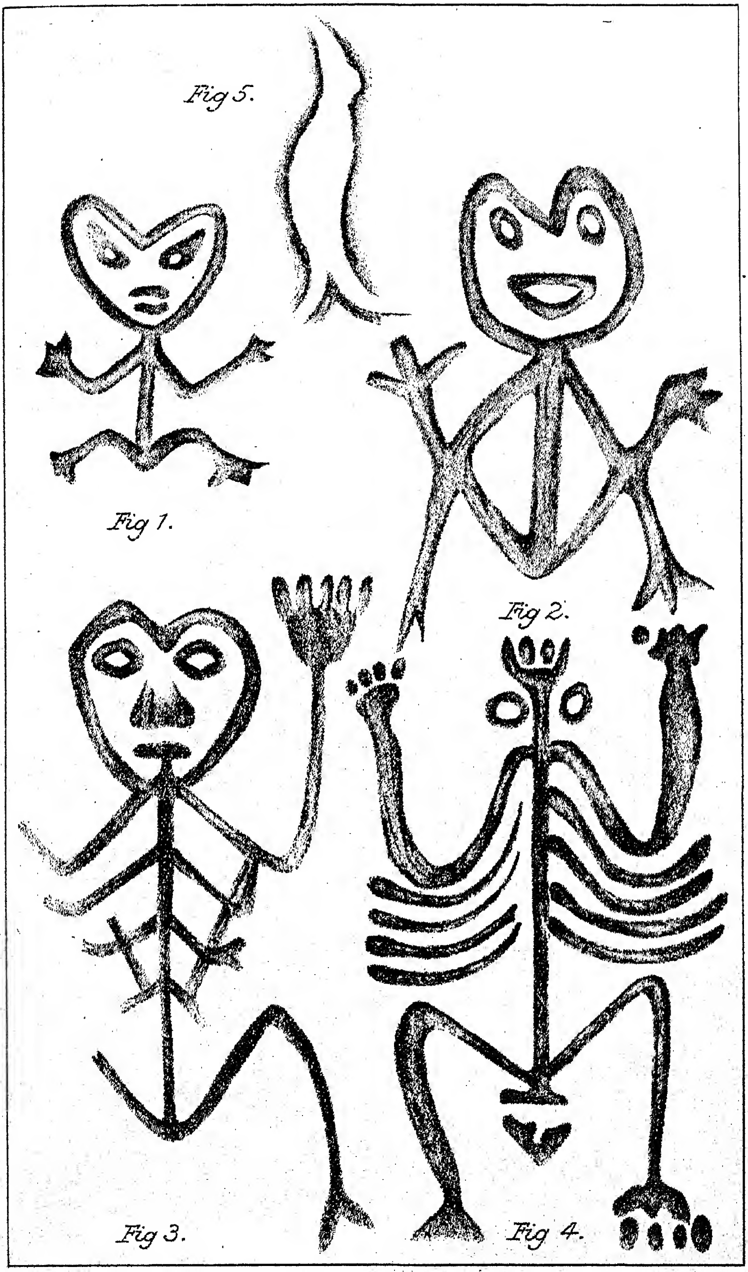


HEALTH STATISTICS.—SEGAR.

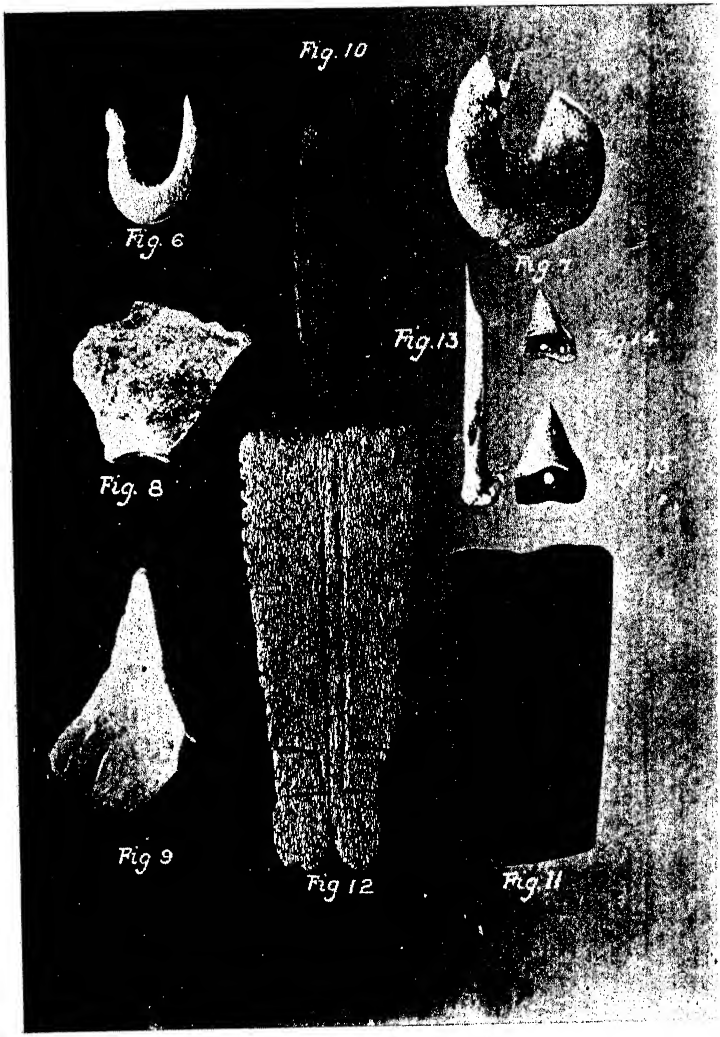

Average yearly number of deaths from cancer per 10,000 of population of each sex of various age-periods.
Males, period 1879–1883, thus
" " 1894–1898, "
Females, " 1879–1883, "
" " 1894–1898, "
Number of deaths.
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
42
44
46
48
50
52
54
56
58
60
62
64
30-35
35-40
40-45
45-50
50-55
55-60
60-65
65-70
70-75
75-80
80 AND OVER.



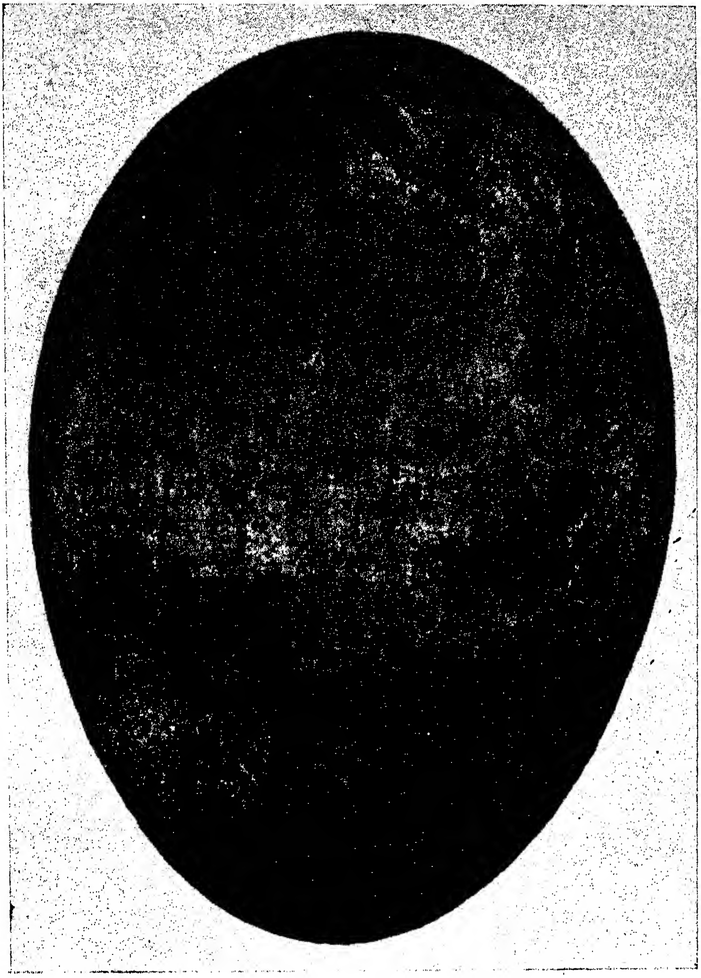
HEALTH STATISTICS.—SEGAR.



MORIORI CARVINGS.—Dendy.

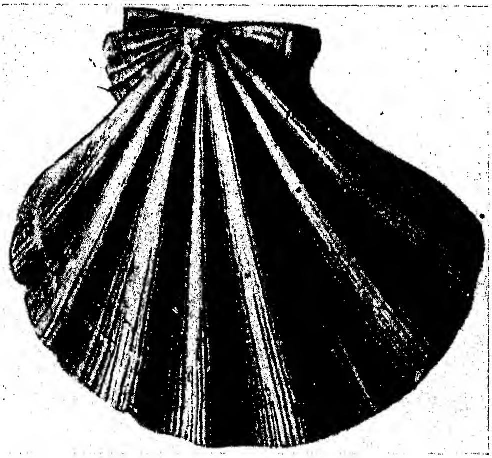


MORIORI RELICS.—Dendy.



MOA'S EGG.—Benham.

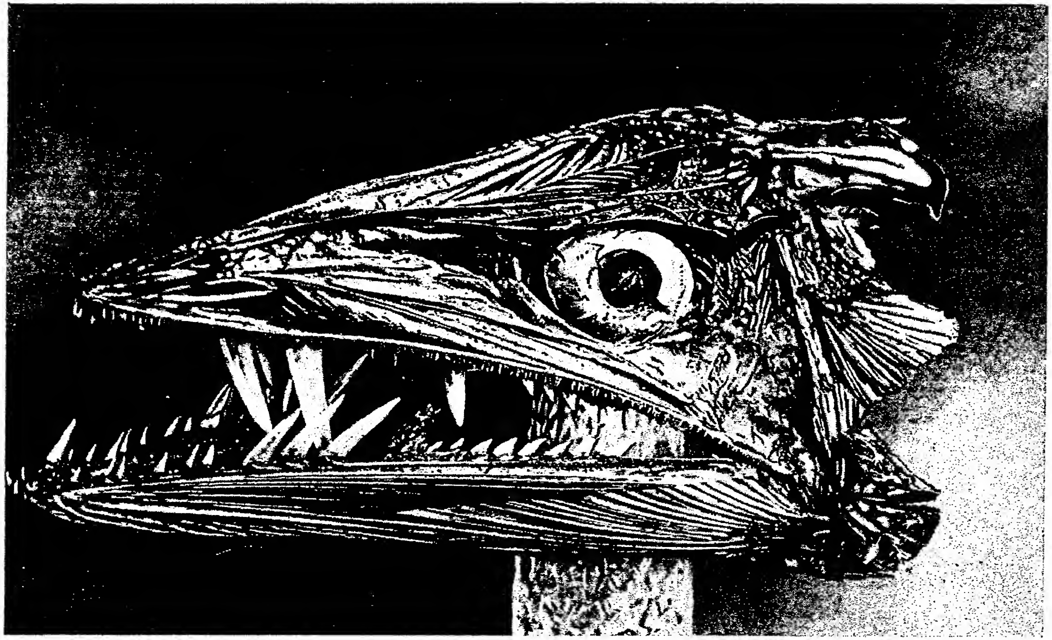
(Reduced.)



Left Valve.

Right Valve.

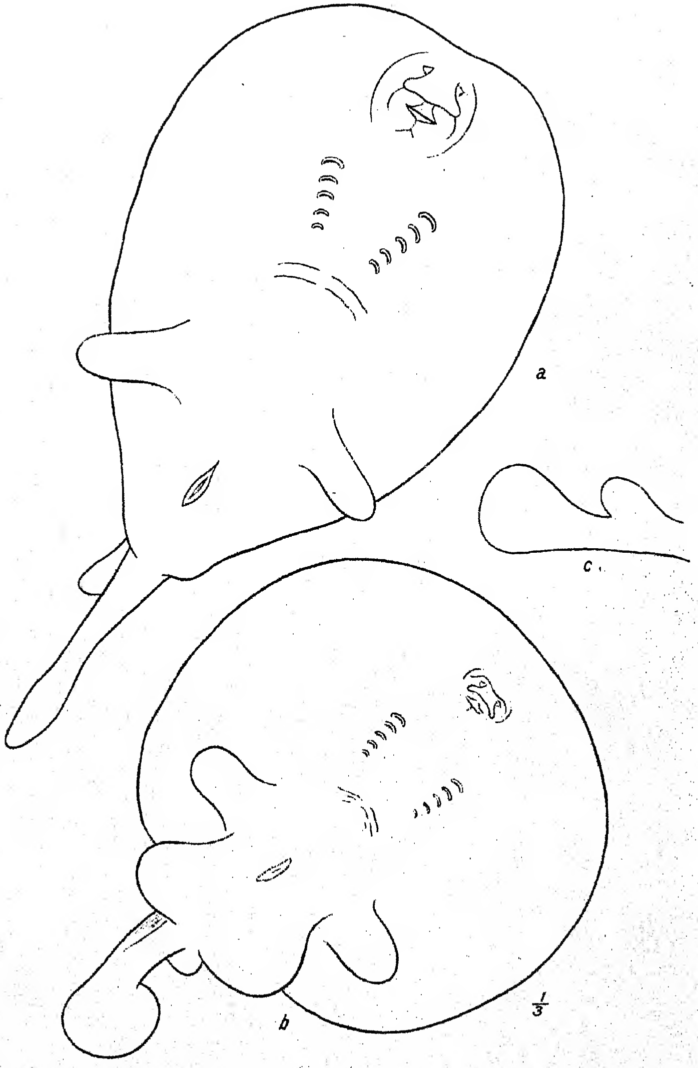
PECTEN DENDYI, n.s.—Hutton.



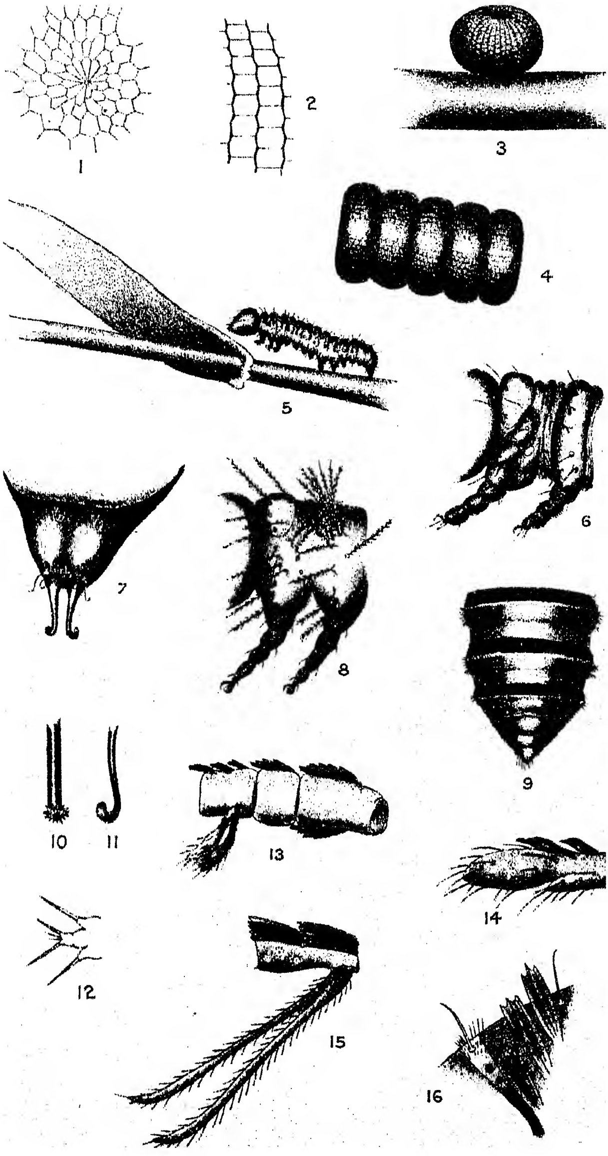
ALEPISAURUS FEROX.—Hutton.

ASTRAPE AYSONI, n.s.—Hamilton.

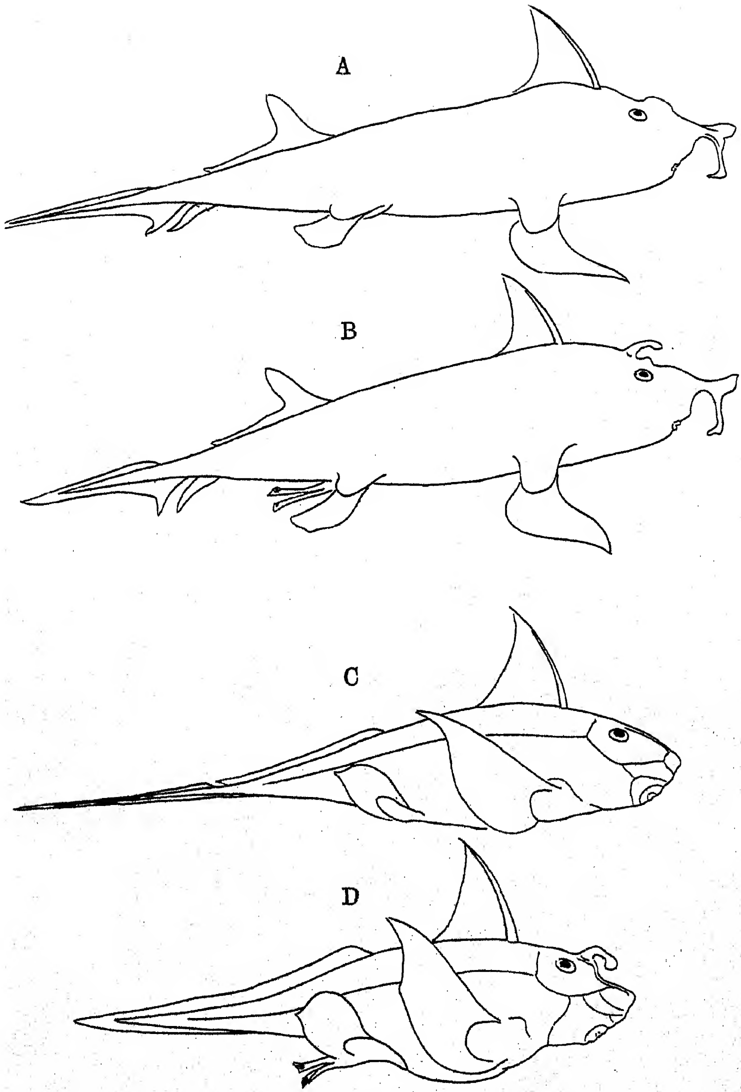
ASTRAPE AYSONI, n.s.—Hamilton.



ASTRAPE AYSONI. n.s.—Hamilton.

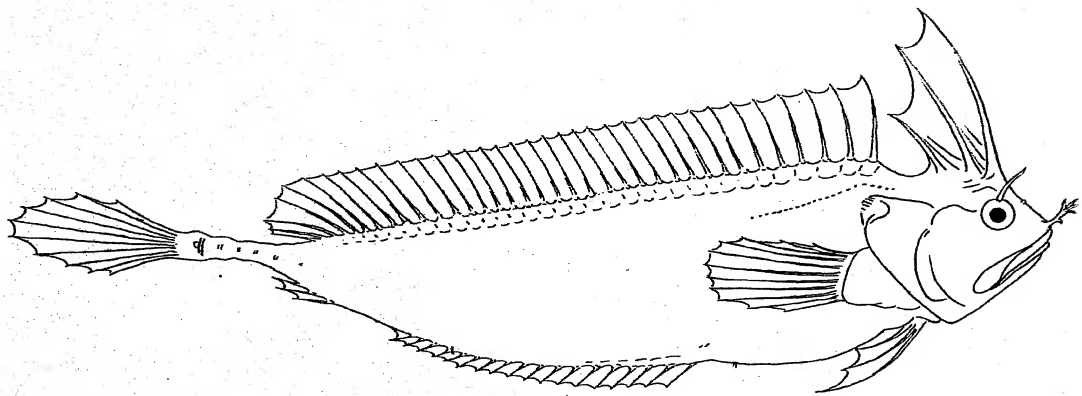


EMBRYO N.Z. LEPIDOPTERA.—A. Quail.



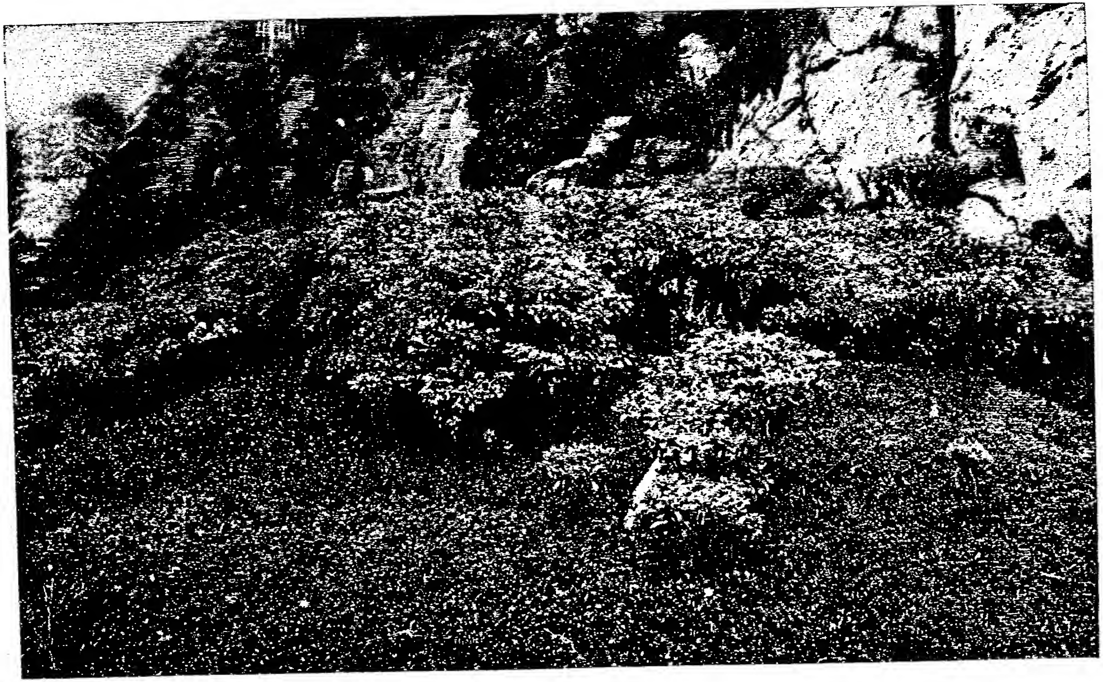
A.—Callorhynchus antarcticus, female. B.—Male.
C.—Chimæra colliei (=C. monstrosa *var.* australis?) female. D.—Male.

NOTES ON N.Z. FISHES.—Hector.



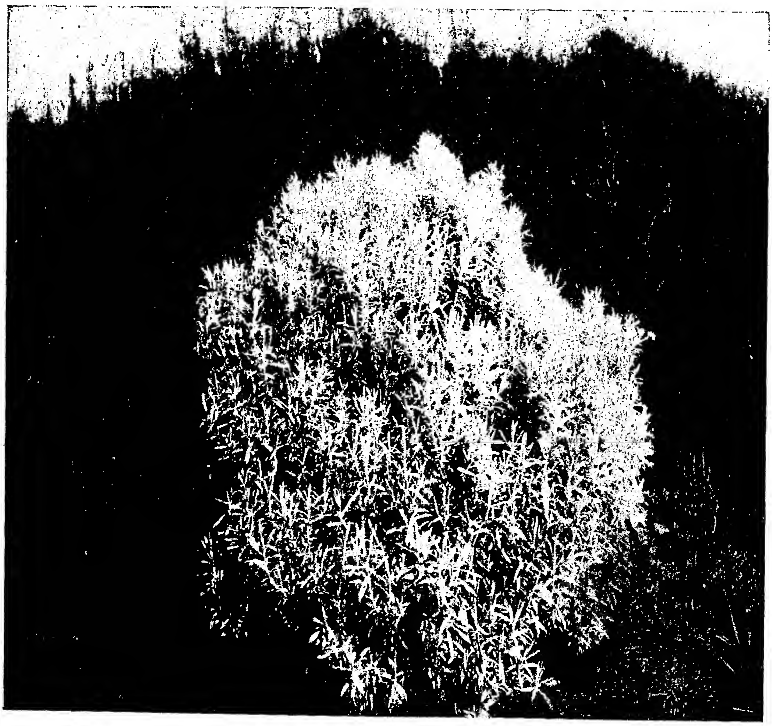
Auchenopterus aysoni, n.s.

NOTES ON N.Z. FISHES.—Hector.

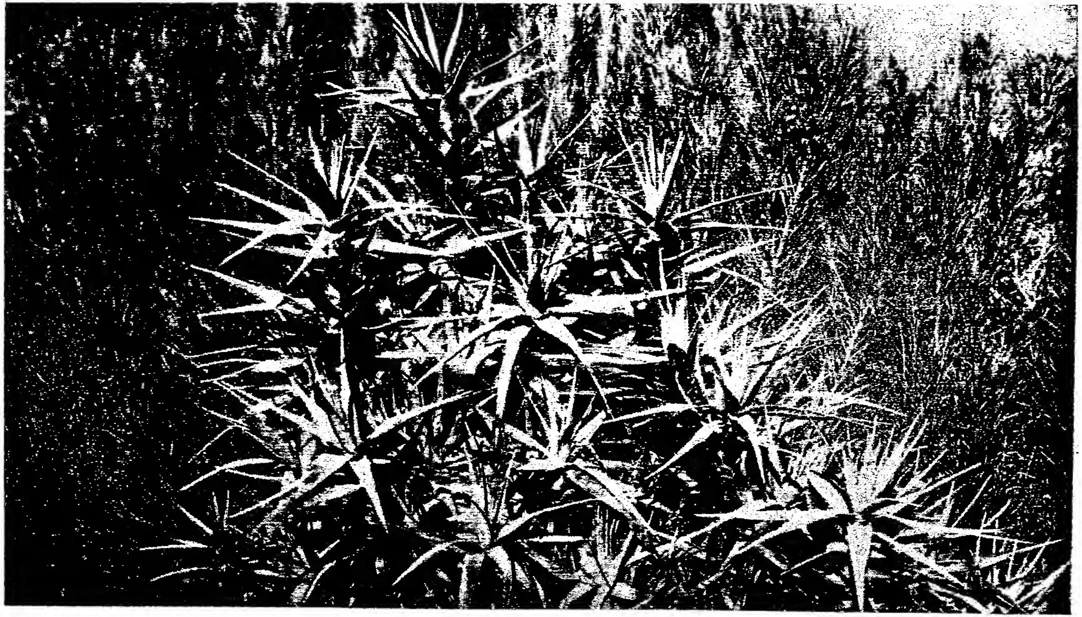


COTULA FEATHERSTONII.—Cockayne.

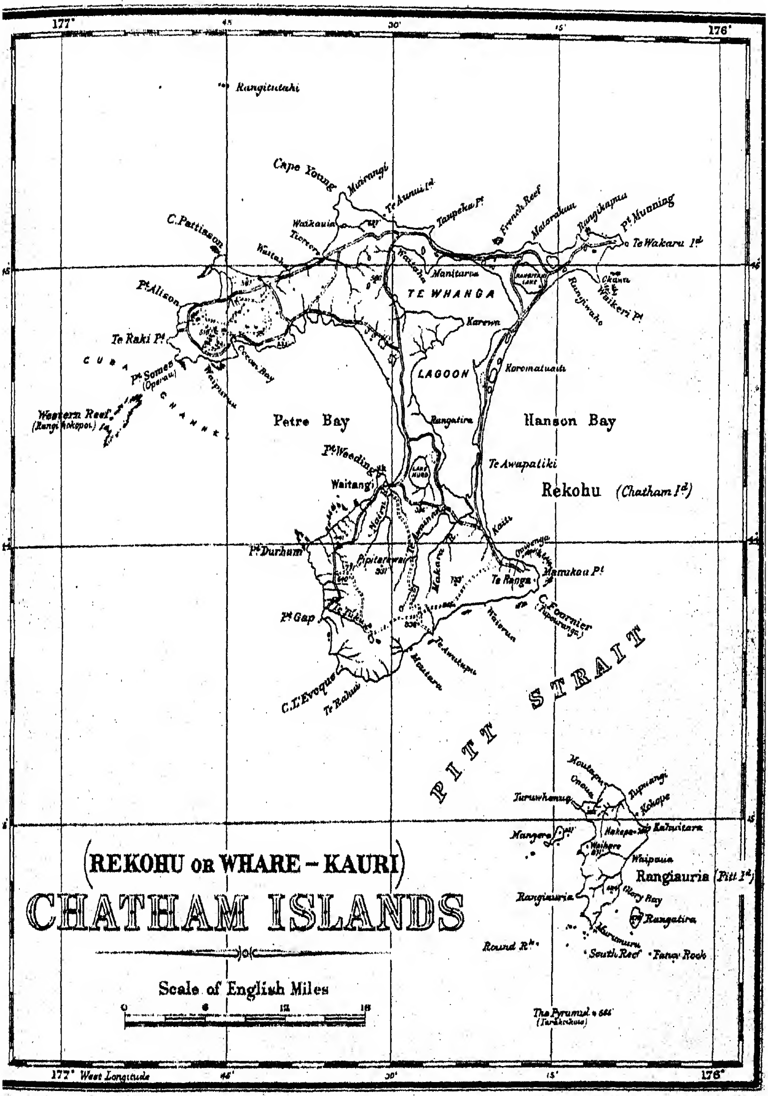
MYOSOTIDIUM NOBILE.—Cockayne.



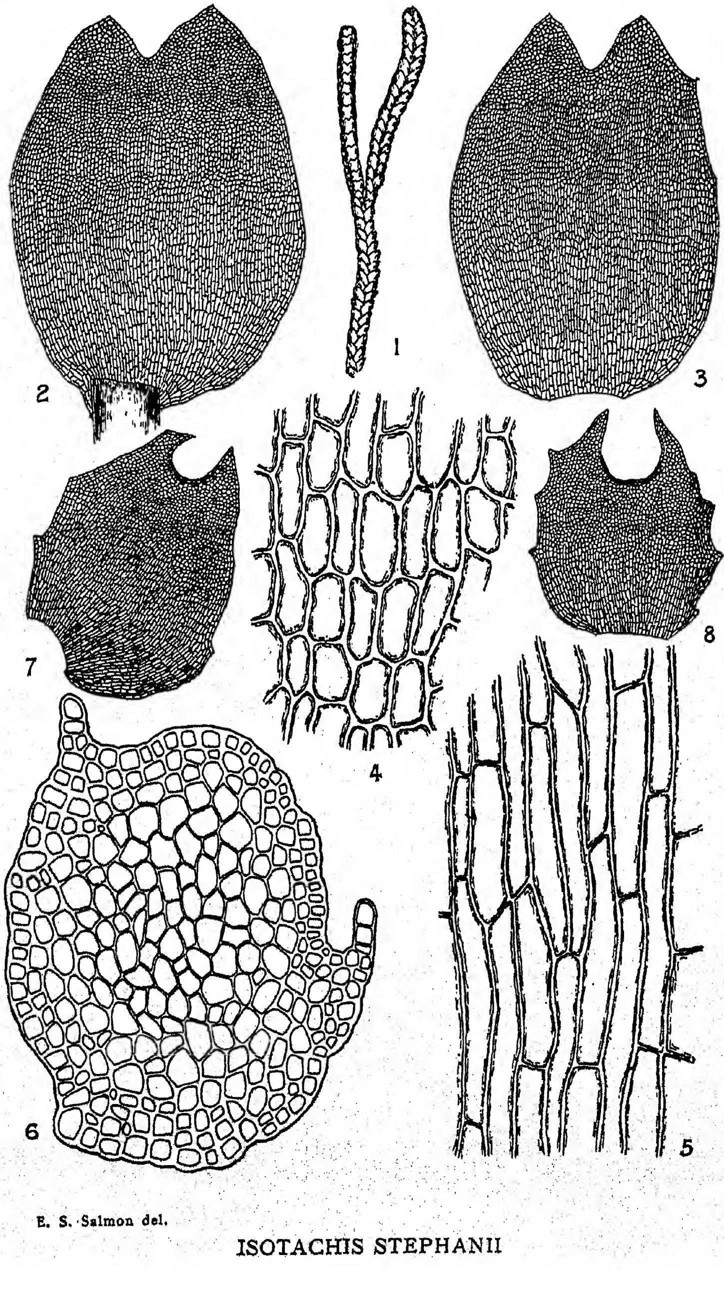
OLEARIA SEMIDENTATA.—Cockayne.



DRACOPHYLLUM ARBOREUM.—Cockayne.



To illustrate papers by A. Dendy and L. Cockayne.



E. S. Salmon del.

ISOTACHIS STEPHANII

Fig. 1.

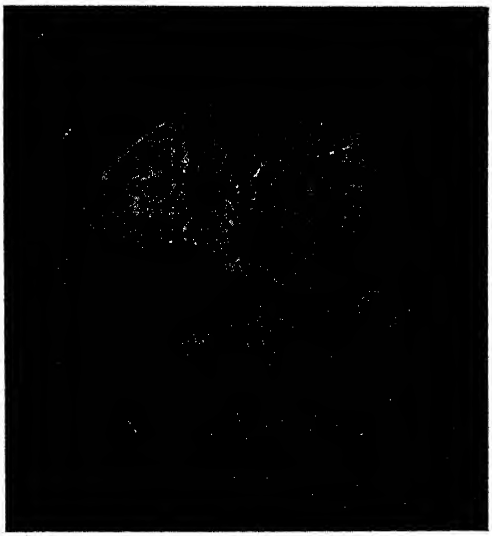
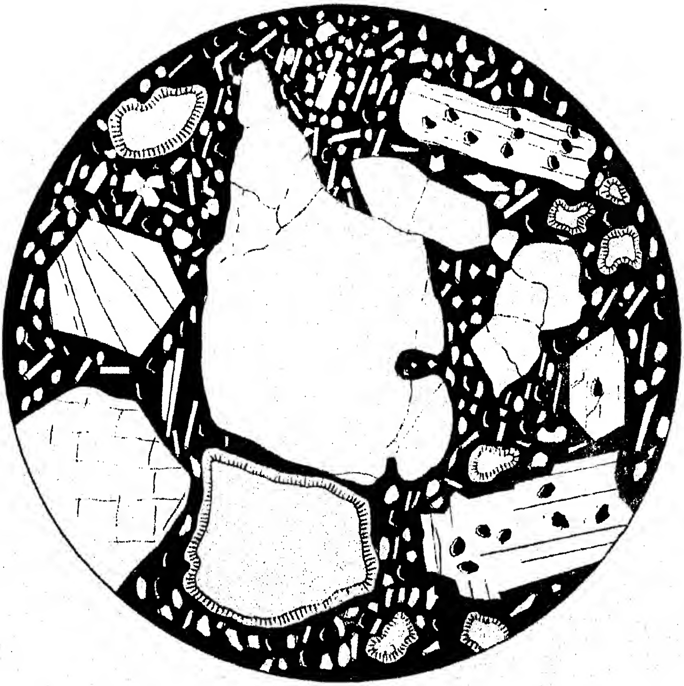


Fig. 2.

CORDICEPS.—Hill.

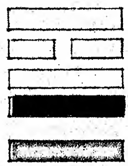
A.

FRAGMENT FROM TAKAPUNA ASH-BEDS.



MAGNIFIED 50 DIAMETERS.

In this and three following plates the ground-mass is largely opaque, but not vitreous, dark matter, probably due to kaolinisation of feldspar.



Altered olivine crystal ... ...

Augite crystals and specks ...

Feldspar crystals ... ...

Magnetite specks ... ...

Crystals having cavities filled with calcite with border of chlorite

B.

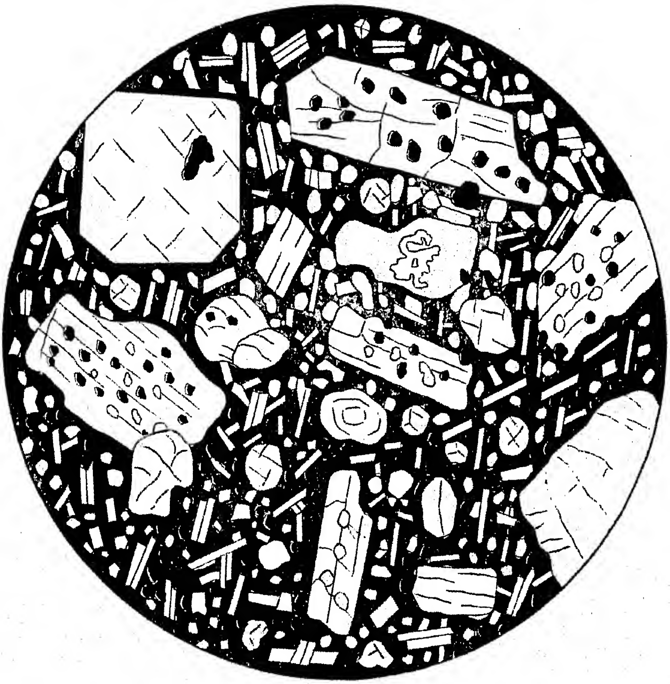
Fragment in Conglomerate from Point East of Whangaparaoa.

Magnified 50 Diameters.

Altered olivine crystals (two shown)
Augite crystals ... ...
Feldspar crystals ... ...
Magnetite specks ... ...
Chlorite lining inside of cavities

C.

FRAGMENT IN GRIT FROM THE HORN, MANUKAU HARBOUR.



MAGNIFIED 50 DIAMETERS.

Augite crystals	
Feldspar crystals	
Magnetite specks	
Cavity partly filled with chlorite ...	

ROCK SECTIONS.—Mulgan.

D.

Fragment in Grit at Cheltenham Beach.

Magnified 50 Diameters.

Augite crystals	...	...	
Feldspar crystals	...	...	
Magnetite specks	...	...	
Chlorite	...	...	

Some of the larger green crystals may be altered olivine, the rest is probably due to the alteration of some pyroxene.

ROCK SECTIONS.—Mulgan.

E.

Mount Eden Basalt.

Magnified 50 Diameters.

Ground-mass vitreous, consisting of small triclinic needle-shaped feldspar crystals and microliths, minute augite crystals and specks of magnetite imbedded in a glassy magma.

Olivine crystals. ... ...

Augite crystals ... ...

Feldspar crystals ... ...

Magnetite specks ... ...

The olivine is abundant; the smaller crystals can only be recognised under crossed nicols.

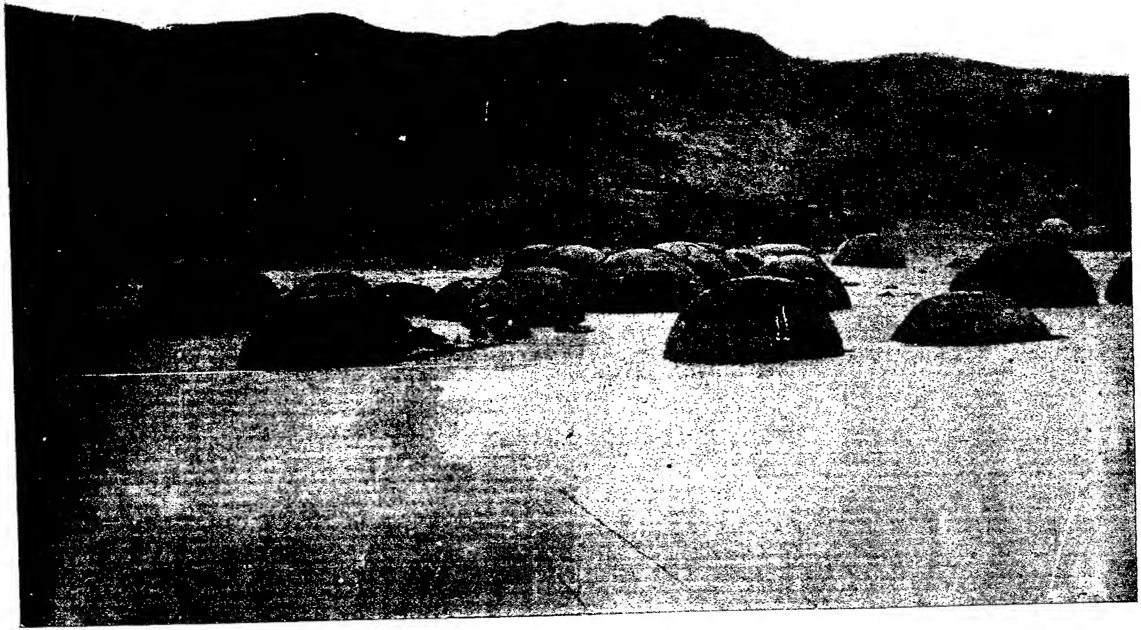
ROCK SECTIONS.—Mulgan.

MORAINES, LEITH VALLEY.—Park.

MORAINES, LEITH VALLEY.—Park.

MOERAKI BOULDERS.—Hamilton.

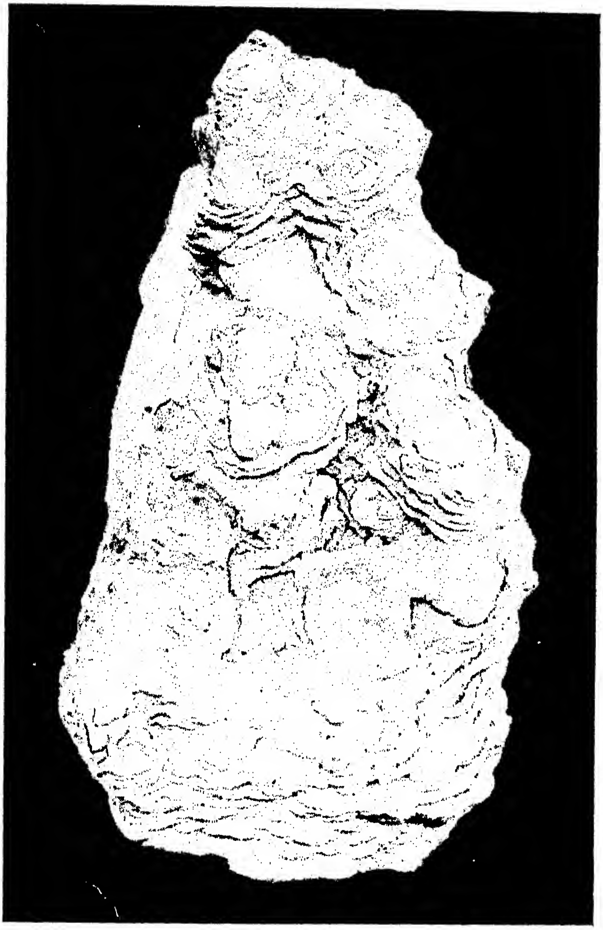
MOERAKI BOULDERS.—Hamilton.



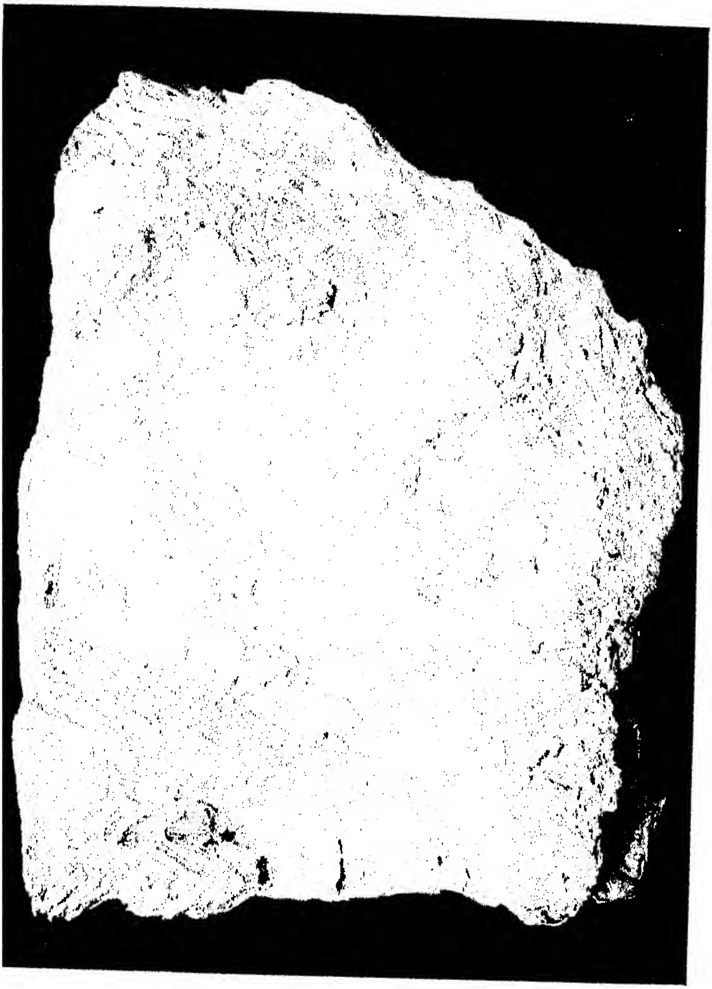
MOERAKI BOULDERS.—Hamilton.

MOERAKI BOULDERS.—Hamilton.

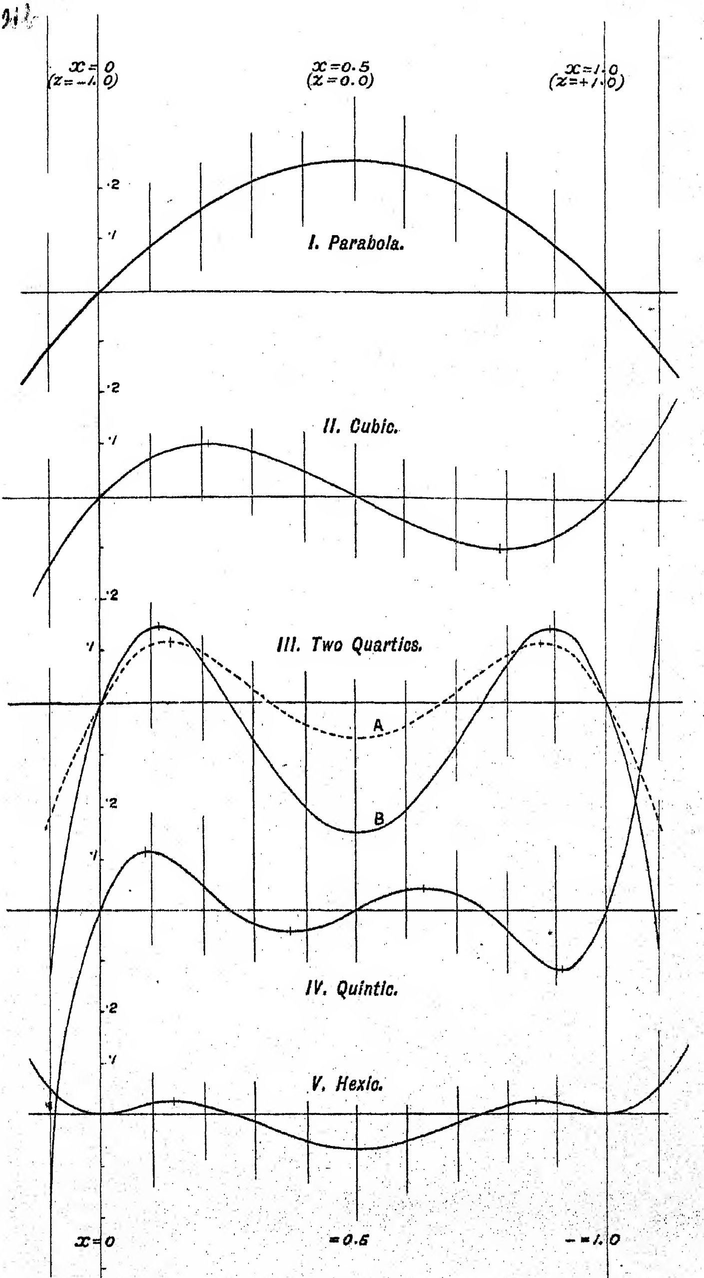
MOERAKI BOULDERS.—Hamilton.



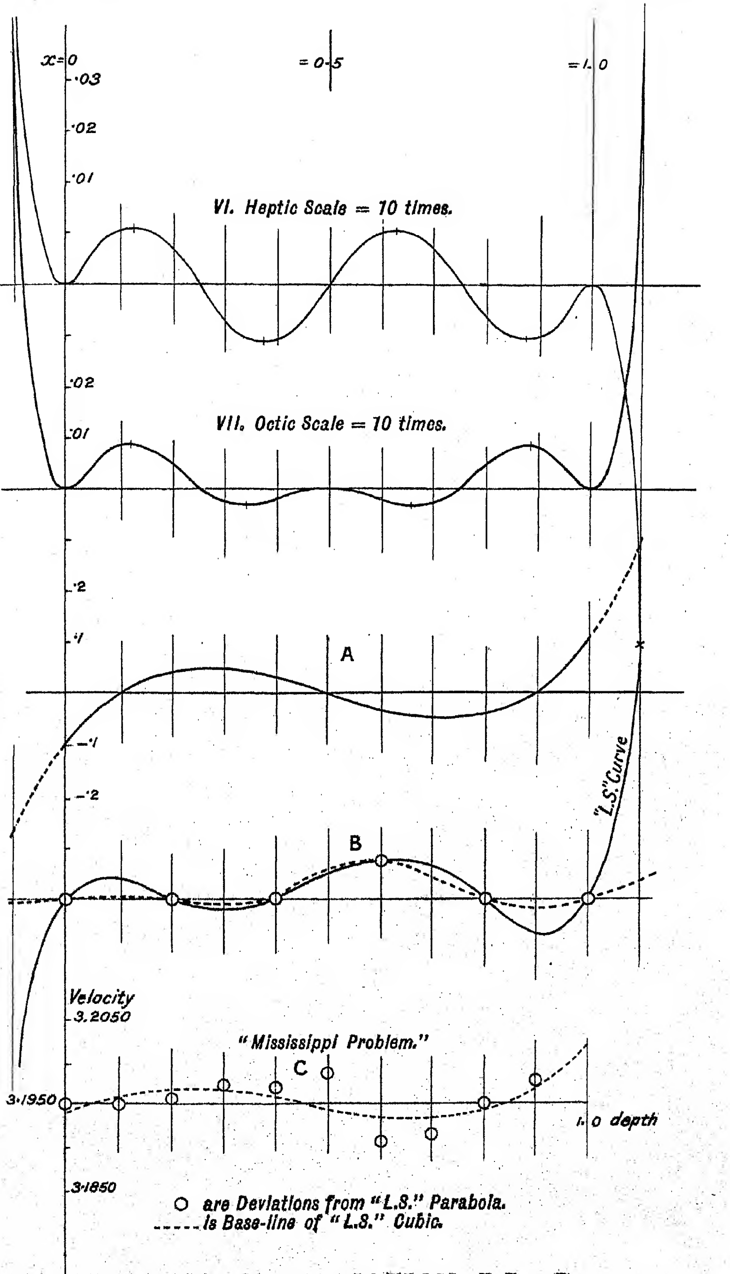
CONE IN CONE-LIMESTONE.—Hamilton.



CONE IN CONE-LIMESTONE.—Hamilton.

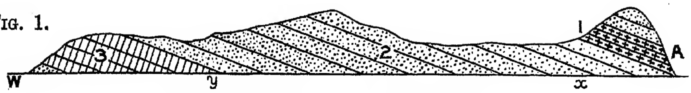


PHENOMENA OF VARIATION P.P.—Brown.



PHENOMENA OF VARIATION P.P.—Brown.

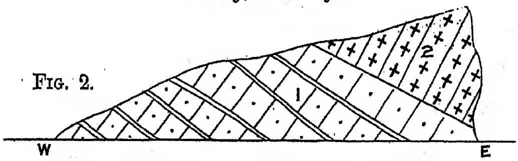
Fig. 1.



A. White Bluff.
1. Parnell grit?
2. Sandstones.
3. Cheltenham breccia?

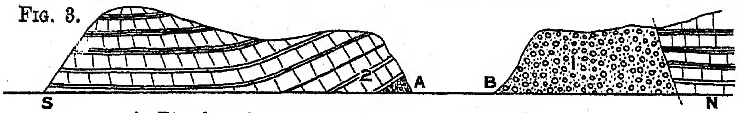
x and y, small bays.

Fig. 2.



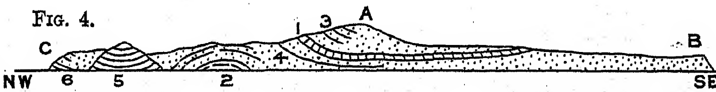
1. Sandstones. 2. Cheltenham breccia.

Fig. 3.



A. Pt. where bryozoa occur.
B. Deep Creek.
1. Breccia.
2. Sandstones and shale.

Fig. 4.



A. St. John's College.
B. Tamaki Gulf (Pt. England).
C. Orakei.
1. Parnell grit.
2. Wairau tuffs.
3. Yellow sandstones.
4. Concretionary grey sandston
5. Pleistocene (?) tuff.
6. Orakei greensand.

Fig. 5.

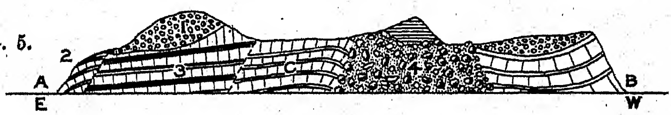
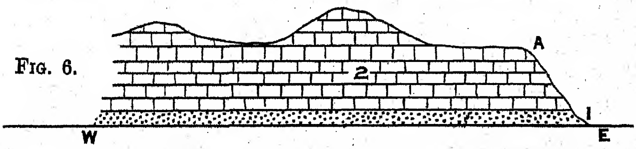
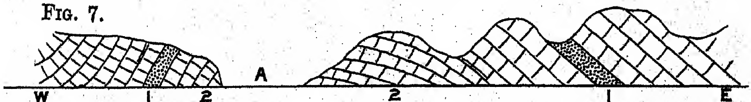


Fig. 6.



A. Cape Horn. 1. Parnell grit. 2. Sandstones.

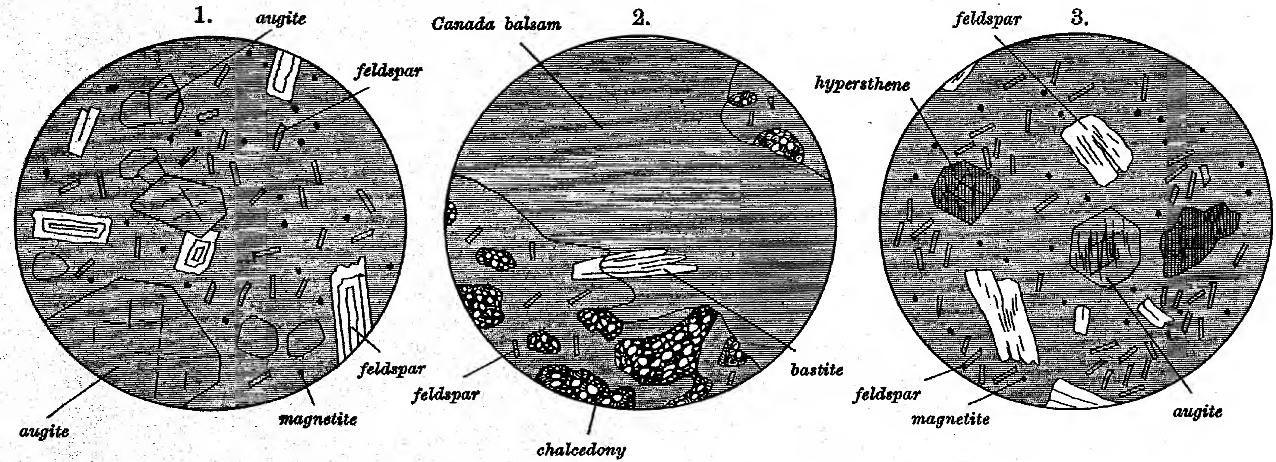
Fig. 7.



A. Blockhouse Bay. 1. Parnell grit. 2. Sandstone.

PARNELL GRIT.—Fox.

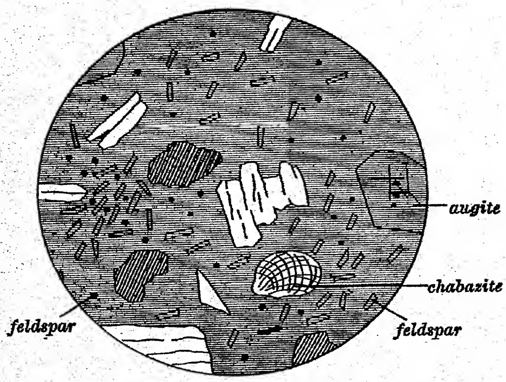
Microscopic Sections of Lava from Cheltenham Breccia (diagrammatic).



PARNELL GRIT.—Fox.

MICROSCOPIC SECTIONS OF LAVA FROM CHELTENHAM BRECCIA (DIAGRAMMATIC).

4.



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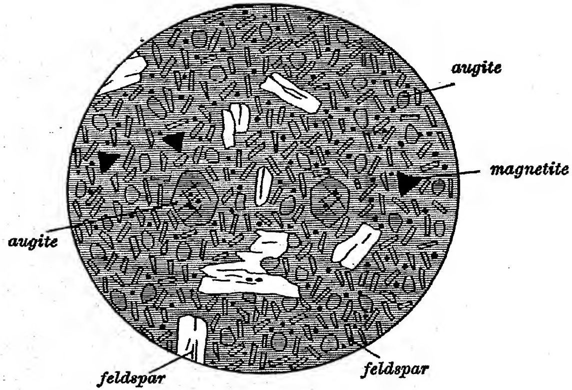
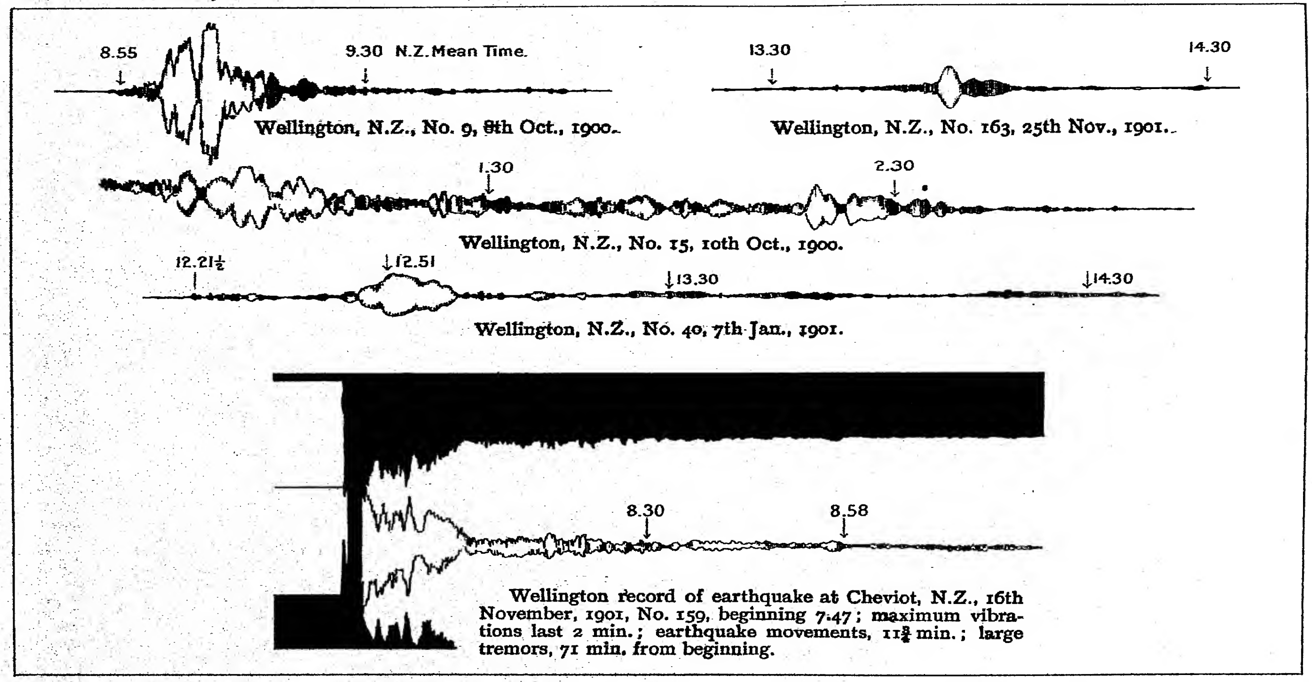
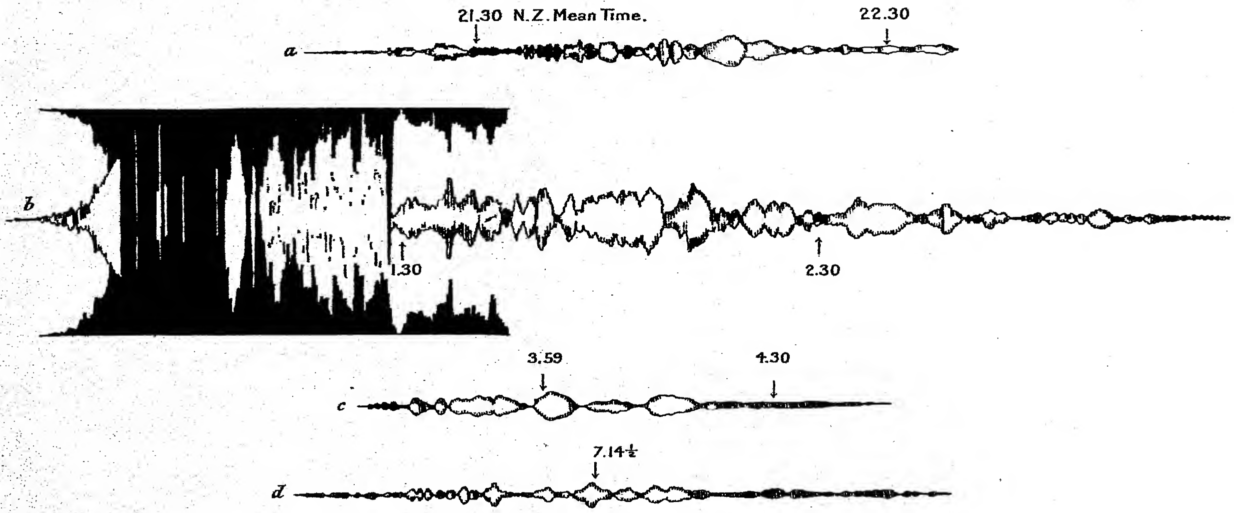


PARNELL GRIT.—Fox.



Wellington record of earthquake at Cheviot, N.Z., 16th November, 1901, No. 159, beginning 7.47; maximum vibrations last 2 min.; earthquake movements, 11¾ min.; large tremors, 71 min. from beginning.

RECORDS OF MILNE SEISMOGRAPH No. 20.—Hogben.



Four records, *a*, *b*, *c*, and *d*, of the Wellington instrument which seem to belong to the same series of vibrations, reaching the instrument by different paths from the origin, the later ones possibly after travelling respectively once, twice, and three times round the earth. Nos. 127 to 130 on Wellington list: *a*, 9th August, 1901; *b*, *c*, and *d*, 10th August, 1901.

RECORDS OF MILNE SEISMOGRAPH No. 20.—Hogben.

WILLIAM SKEY.

See p. 554.